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SUMMER SCHOOL FOR ENGINEERING TEACHERS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION TO BE INAUGURATED BY TWO SESSIONS IN 1927

Dr. F. P. Keppel, President of the Carnegie Corporation, announces that the executive committee of the Corporation has recommended a special draft to the Society of the funds needed to conduct a summer school for engineering teachers during the coming summer. This makes possible the realization and inauguration of a project which has been considered as one of fundamental importance in the betterment of engineering teaching. It is an outgrowth of the Society's investigation of engineering education which has been in progress during the past three years.

The desirability of establishing the school was suggested by Director W. E. Wickenden as a result of his inspection of a similar school administered by the Board of Education of England. It was considered by the Committee on Teaching Personnel, under the chairmanship of Dean C. H. Warren of Yale University, and formally recommended by that committee to the Board of Investigation and Coordination as a project which should be undertaken at as early a date as possible. When the project was shown to Dr. Keppel for comment and suggestion as to where funds to conduct it might be sought he proposed that he recommend to the Carnegie Corporation that it supply the funds for the initial sessions of the first year.

At the present moment announcement can be made of the general plan. This will be followed by detailed statements regarding the programs of the school as soon as they are determined upon. During the coming summer the school will be conducted under the general supervision and direction of the Board as a part of its coordinated program of development. It is proposed that the school be held immediately

after the annual convention of the Society at Orono, Maine, which is scheduled for the last week in June. It is planned that the duration of the school will be two and one-half or three weeks and that two sessions will be held simultaneously. Negotiations have been opened with Cornell University through Dean Dexter S. Kimball and with the University of Wisconsin through Dean F. E. Turneaure as sites for these two sessions.

The work of the summer schools will center around the teaching of particular subjects. Attendants will in general be the younger teachers in the subject to be considered. The number at each session will be limited to an efficient working group. There will be a staff of outstanding teachers and the work will be conducted on an intimate basis; much of it by the seminar method. The Associate Director, Professor H. P. Hammond, will develop the immediate plan and have intimate charge of the project.

The subject selected for the first sessions is one of basic importance to all branches of engineering, namely, mechanics. Teachers of both pure and applied mechanics will be invited to attend. Members of the staff will be qualified to deal with each of several divisions of the work:

(*a*) The teaching of mechanics (analytic mechanics or pure mechanics).

(*b*) The teaching of the applications of mechanics in related fields.

(*c*) The exposition of methods of teaching in general.

The bringing of groups of the ablest and most promising younger teachers into contact with leaders having different points of view and different methods of presentation with adequate opportunity for free discussion promises a forward step in methods of teaching, in developing and holding the interest of the student, and in putting new life and inspiration into this department of engineering training.

It is expected that the tuition charges will be limited to a nominal registration fee and that the costs for subsistence

and housing will be kept as low as is consistent with suitable environment and meals.

Details of methods of applying for enrollment and of the selection of those who attend, the exact dates of the sessions, the names of the staff and other matters now under active consideration will be decided in the near future and due announcements will be made through the columns of the JOURNAL and by means of circulars.

Correspondence should be directed to the office of the Director of Investigation, Society for the Promotion of Engineering Education, Engineering Societies Building, 33 West 39th Street, New York City.

It is believed that the Society's school for engineering teachers will constitute the initial undertaking of its kind in the United States. It is the first concrete step arising out of the investigation for the improvement of teaching methods and the training of engineering teaching personnel. The undertaking may prove of significance in the general field of higher education for the professions.

CHARLES F. SCOTT,

Chairman, Board of Investigation and Coordination, S. P. E. E.

MORE MEMBERS! MORE BRANCHES! MORE SECTIONS! WHY?

W. S. RODMAN

Vice President of the Society, Chairman of the Committee on Sections and Branches

A thoroughly Utopian conception of the S. P. E. E. would disclose a membership including all individuals somewhat closely concerned with the preparatory training, the professional instruction, and the employment of the engineers of the future as they climb the ladder from youth to maturity. Such a personnel, working cooperatively, would assure recognition of every aspect of the subject of preparation for a life of maximum happiness and usefulness. Subject to local environmental, economic and psychological conditions, this broadly representative membership would bring about eventually the closest possible approach to a highly idealistic yet practicable solution of the manifold problems so intertwined in the important field of engineering education.

The visionary goal cannot be reached but it should be relatively simple to bring about a much closer approximation to it than now exists. In the particular field of professional instruction there should be practically a full membership. Teachers of engineering students, in the basic, technical and humane subjects, should be members of that Society which is above all their professional Society. Other teachers, who in one way or another are concerned in the instruction of young engineers as a part of their duties, should be members in order to be in a position to work in cooperation intelligently and with the least loss of effort to assure the integrity of the final product, the engineer-to-be. From these two groups should spring the strong sustaining nucleus of the Society.

Highly important also is a representation from preparatory schools and from institutions giving essentially pre-engineer-

ing instruction, for such members would serve as important liaison agents to insure a better prepared and more wisely guided group of entering students than is at present found. This group will probably never be large in numbers but at least it should be possible to build up this membership to a point where a real coordination between preparatory and professional training would result.

At the opposite end of the path it is equally important that a much larger membership from industry and practicing professional ranks should be obtained so that through mutual understanding and by the use of methods based upon facts rather than theories a better opportunity would be presented for arriving at more generally satisfactory solutions of many vexing problems.

These increases in membership can and should be brought about. A variety of excuses presented in past years for not becoming a member are now for the most part invalid. The cost is small, the opportunity for real service is large, and benefits are bound to accrue to those who contribute in some way, large or small, to the welfare of a Society so intimately related to the engineering teacher and the engineering practitioner.

It is first essential that the body of teachers support the cause as a unit, thus providing a solid formation which will go far to influence non-teachers to cooperate. Increases in the teacher membership can be obtained in practically every one of the institutions in this country if some real effort be made to that end. The very fact that additions have been reported during the past few months ranging from one or two to as many as twenty new members per institution is clearly indicative of what could be accomplished in this particular field. The least contribution that could be made by present members would consist in a sturdy effort to bring non-member colleagues, representatives of preparatory schools, and of industry into the Society as active members. Who will prove most able in this regard? It is a worthy race to enter and each contributor may feel that the individual effort, multiplied

again and again throughout the country, has made the foundation of the S. P. E. E. more solid and substantial.

The fact that this Society is now in a position to determine the future trend of Engineering Education, basing its program on facts rather than theories, thanks to the three-year fact-finding task so thoroughly carried on and nearly completed, presents a unique opportunity not liable to come again soon if now allowed to pass unutilized. This opportunity lies in contributing to real and vital solutions of many troublesome problems presented in the training and preparation of young engineers for one of the main, if not actually the most important, group of professional citizens.

The Utopian Society would find itself with a Branch organization in each institution concerned with the training of engineers. Already Branches in several institutions have been functioning ably and have proven their worth. Wherever the Branch has been given a fair trial under active officers the continuance of meetings shows that value has been received. Many more Branches should be established, officered by enthusiastic leaders, since such organization can and should fill a place in the activities of an engineering school which cannot be so well cared for by any other agency.

An active Branch, with carefully prepared programs and open and complete discussion of the myriad of problems and questions continually presented, local and general, can not fail to be of value to those taking part in its activities. It is true that the conduct of Branches involves work and plenty of it, but it is impossible to accomplish anything worthwhile without effort, and that effort necessary to get results should properly be regarded as a part of ones daily mite which in the aggregate will account for untold returns.

Will not each local group of members in institutions without active Branches give the matter of formation of such a unit serious consideration and a fair chance to prove its value, rather than to condemn it untried as an undesirable burden or a worthless activity? The very presence of an active Branch will do much to interest and bring into membership

many who are now outside because of a feeling that no active contact with the Society is possible for them.

Proceeding still further into the organization of the Utopian S. P. E. E., one visions a further cooperation and contact of all interested members by the banding together in Sections of the various institutions in fairly contiguous territory. The ideal condition would be for every institution to have a part in a Section activity. Extremes of distance and financial consideration make it too much to hope that such a complete organization can be effected soon, but already nuclei have been established and enthusiastic Section meetings held for a period sufficiently long to prove their worth. Such meetings naturally are not held often, but even once or twice a year will serve to knit the group together and provide much needed opportunity for closer personal relations between individuals with mutual interests.

Rotation of Section meetings among the constituent institutions makes possible at relatively frequent intervals the full contact of member with Society which is so essential for producing the stronger feelings of reality of purpose and common grounds of interest which alone can produce an able cooperative activity. Section meetings become the natural occasions for bringing together members representing all engineering interests from preparatory-course teachers through to industrial representatives, in various parts of the country and in a more complete manner than a single annual meeting can hope to accomplish. Suggestions regarding an enlargement of Section activity are being presented to the institutions of the country and it is to be hoped that a very real response may be obtained.

The Utopian vision has still further activities which may well be brought into being if only the solid foundation of larger membership and increased Branch and Section activity be well established. These further visions may well await disclosure at some auspicious future occasion when conditions seem more nearly fitted to make their consideration profitable.

The field of Engineering Education is bound to be an

evergrowing one, with new problems arising for solution and with new questions demanding answers. The task of solving these problems and of answering these questions wisely is essentially one which should be borne by the entire membership working in closest cooperation and harmony.

What greater satisfaction could be felt than that of having contributed in some measure to the working out of means whereby there shall be brought about a better preparation of entering students, a wiser guidance toward a life-work, a nicely adjusted and balanced course of training, all of which shall furnish a group of graduates better fitted for a life of usefulness and with marked decreases in the mortality en route?

Should not one take pride in being an agent in a cooperative enterprise which, carried to success, will mean for both teachers and students added prestige, enhanced power for good, enlarged financial remuneration, and from the public at large a more universal appreciation of the real place of the engineer in the world of to-day and of to-morrow.

The goal set is a high one, but an eminently worthy one to which to aspire. The task is not a hopeless one but will require able and concerted effort. Let the foundation be well laid and see to it that each adds his mite of mortar or of stone in order that the structure may be established as true and fine.

More members, more Branches, more Sections, each active and striving toward the goal will accomplish wonders. There is no better time to start than the present. This race is on. Let us away!

THE COOPERATIVE METHOD OF ENGINEERING EDUCATION *

Purposes.—In the twenty years since its establishment at the University of Cincinnati, the cooperative method has passed through an initial stage of trial and experimentation and has now made a permanent place for itself in engineering education. Whatever may be believed of the merits of the plan, its advent appears to constitute one of the major developments in engineering education in the past quarter-century. The time seems ripe to attempt an appraisal of the system.

There has been much discussion of the cooperative plan, both oral and written, since its inception. This has consisted largely of descriptions of the methods of conducting cooperative courses in particular institutions and of opinions of the merits of the system advanced by its advocates. There has been little in the way of a comprehensive summary of the situation or a critical appraisal of values. The purpose of this study is to supply these deficiencies in so far as possible by presenting the important facts relating to cooperative courses; by analyzing those facts in relation both to the methods and to the principles involved; by gathering and weighing opinions of those competent to express themselves; and finally by presenting such conclusions as the facts and opinions seem to warrant.

Scope.—For the purpose of this report the term "cooperative engineering curriculum" is applied to a curriculum of predominantly engineering character, leading to a degree, which provides for the alternation at regularly scheduled intervals of periods of instruction in college and of super-

* Bulletin Number 12 of the Investigation of Engineering Education.
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vised and correlated experience in industry. The study deals only with curricula so defined, and does not include the application of the cooperative principle in other fields of education. This accords, in general, with the limits of the investigation as a whole, and was necessary in order to fix a boundary to the present study. It is probably pertinent to add that the cooperative principle has found more widespread application in engineering than in any other field of higher education.

The study has been divided into four principal divisions as follows:

I. General data concerning cooperative courses,
II. Organization and administration of cooperative courses,
III. Appraisal of value of the cooperative system,
IV. Review of literature on the subject.

Auspices and Methods.—An invitation was extended to the faculty of the Polytechnic Institute of Brooklyn to conduct a study of cooperative engineering training as its contribution to the Society's general investigation. The invitation was cordially accepted and the following committee was appointed to carry on the work:

Erich Hausmann, *Chairman*,
Edwin F. Church, Jr., *Secretary*,
Robin Beach,
Harry P. Hammond,
Clarence W. Hudson,
John C. Olsen,
S. Marion Tucker,
Parke R. Kolbe, ex-officio,
Ernest J. Streubel, ex-officio.

The committee gathered a considerable body of data and opinion relating to cooperative courses. Much of this information was collected by means of questionnaires. Other data were abstracted from official catalogues and confirmed or amplified by correspondence where such step was necessary. Visits were made to a number of representative institutions and numerous conferences were held with persons interested

in or familiar with the plan and its results. An extensive search was made of the literature on cooperative courses.

The results of this work were compiled and studied by the committee and a summary was presented as a preliminary report at the annual convention of the Society in June, 1926. Copies of this report are available in limited numbers at the office of the Director of Investigation, Society for the Promotion of Engineering Education, 33 West 39th Street, New York City.

The committee preferred not to submit any statement of its views on the value of cooperative engineering training in connection with the present document, and has therefore confined its report to statements of fact and to quotations of the opinions of others.

The report submitted by the committee has been taken as the basis of data upon which the present document has been prepared by the Staff, as named elsewhere. The facts and opinions compiled by the committee have been incorporated, with certain rearrangements and some additions, in Parts I, II, and IV of the present report. The quotations of opinions as to the advantages and disadvantages of cooperative courses were also compiled largely from material gathered by the committee. All inferences and conclusions in Section D of Part III of this report have been written entirely by the Staff which accepts full responsibility for the statements made. Findings and recommendations of the Board of Investigation and Coordination as to cooperative courses will be included among other recommendations of the Board which will appear separately.

PART I. GENERAL DATA RELATING TO COOPERATIVE COURSES

The combination of practical experience with scholastic training has been advocated as a desirable educational method many times in the past, and several plans for accomplishing this end have been instituted in certain divisions of the general field of education. The so-called "sandwich plan," which provides opportunity for the engineering apprentices

of Scottish industries to obtain a technical education by attendance at educational institutions during certain months of the year, is an example of such a plan in the field of engineering education. Cooperative engineering courses as conducted in the United States are, however, a distinctive type of educational program for which little or no direct precedent can be found. It is probably both fitting and accurate to credit not only the inception of the idea of such courses but also the position which the plan occupies in this country at present in large measure to the ability, resourcefulness, courage, and consistency of purpose of Dean Herman Schneider who first established cooperative engineering courses at Cincinnati in 1906.* At that time the cooperative option (all-resident curricula were continued until 1919) was chosen by 27 of the 134 engineering students then enrolled in the institution. Since that time the number of institutions offering such courses has grown from one to sixteen,† and the number of students enrolled under the cooperative plan in 1925–26 was approximately 5,500. As the total number of colleges in the United States which offer curricula in engineering leading to degrees is now between 150 and 160, it is seen that approximately ten per cent of these colleges now offer cooperative courses. The number of students enrolled in cooperative courses is also approximately ten per cent of the total enrollment of engineering students in the country.

Number and Types of Institutions Offering Cooperative Courses.—Table I lists the sixteen institutions which offer one or more engineering curricula on the cooperative plan in which there is any considerable enrollment of students. The table also gives the types of institutions and indicates abbreviations which will be employed for convenience in referring to the institutions in this report.

* For a more complete statement regarding the inception and development of the plan at the University of Cincinnati see "The Cooperative System of Education" by Clyde W. Park; University of Cincinnati Studies, Series II, Volume XI, Part I.

† Since the original compilation of the data of this report, two additional institutions have announced the establishment of cooperative courses. See also footnote on page 673.

TABLE I *

Name.	Type.	Abbreviation.
Municipal University of Akron.	Municipal university	Akron
University of Cincinnati.....	Municipal university	Cincinnati
Detroit Institute of Technology	Y. M. C. A. institution	Detroit Inst.
University of Detroit.....	Sectarian university	Detroit Univ.
The Drexel Institute..... (Philadelphia, Pa.)	Endowed technical college	Drexel
Evansville College (Indiana).	Sectarian college	Evansville
Georgia School of Technology. (Atlanta)	State supported polytechnic institute	Georgia
University of Louisville.....	Municipal university	Louisville
Marquette University..... (Milwaukee, Wis.)	Sectarian university	Marquette
Massachusetts Institute of Technology (Department of Electrical Engineering).. (Cambridge, Mass.)	Endowed polytechnic institute	M. I. T.
New York University.....	Endowed university	N. Y. U.
Newark Technical School..... (New Jersey)	Municipally and state controlled college of engineering	Newark
University of North Carolina.. (Chapel Hill)	State university	No. Carolina
Northeastern University..... (Boston, Mass.)	Y. M. C. A. institution	Northeastern
University of Pittsburgh.....	Endowed university	Pittsburgh
Southern Methodist University. (Dallas, Texas)	Sectarian university	So. Methodist

* Since the compilation of the above list, the Cleveland Y. M. C. A. School of Technology has increased the length of its cooperative curricula in engineering from three to five years and now confers the degree Bachelor of Science.

The University of Tennessee announces that beginning with the session 1926–27, engineering students may choose either a regular four-year curriculum, or a five-year cooperative curriculum. The first year of the latter will be on the all-resident plan, followed by four years of cooperative training. Alternation between college and industry will be at intervals of the University term of twelve weeks.

Certain institutions and curricula studied by the committee are not included in the above list for reasons set forth in the following notes:

Antioch College offers genuinely cooperative curricula and maintains a department of engineering. Students may elect engineering as their "field of concentration." Complete curricula in engineering are not offered, however, on a basis comparable with those of the sixteen institutions listed. Of a total of 225 term credits required for the degree Bachelor of Science but forty-four are in specified engineering subjects and ten are in engineering electives. The proportion of engineering subjects provided in the Antioch curriculum is approximately twenty-five per cent, while the proportion in other colleges offering engineering courses averages approximately fifty-five per cent. It is therefore believed that the Antioch curriculum is such that it is better classed as a general scientific course with engineering as one of its elements rather than an engineering curriculum in the usual meaning of that term.

Carnegie Institute of Technology offers by agreement with the United States Bureau of Mines, the State Department of Mines of Pennsylvania, and the bituminous coal mining industry of the Pittsburgh district a post-scholastic training program of three years duration and confers the degree Engineer of Mines upon those successfully completing the program. The work is not, however, such as to be designated a "cooperative engineering curriculum" as previously defined.

Lafayette College offered a regularly organized cooperative course in mechanical engineering during the years 1922 to 1926 inclusive, but abandoned the plan in the latter year. The number of students who pursued this course was so small that it has been omitted from the tabulations. Further note regarding the trial of cooperative courses at Lafayette will be found on pages 678 and 679.

Worcester Polytechnic Institute offers an optional arrangement whereby students may take a course of non-resident engineering experience of fifteen months duration between the junior and senior years of the curriculum. Such students are placed with engineering organizations and follow a course of experience and training which has the approval of the Institute. The students are regularly in touch with their department of instruction at the Institute (Electrical, Mechanical, etc.) through letters and reports and through visits from members of the Institute staff. The Institute's official catalogue for 1926–27 lists four students of electrical engineering who are pursuing this option.

The Massachusetts Institute of Technology School of Chemical Engineering Practice.—In addition to institutions and curricula listed in Table I and to those mentioned in the paragraphs which follow the table, the curriculum offered by the Massachusetts Institute of Technology in its School of Chemical Engineering Practice should be discussed in connection with this report. The course is in a sense cooperative, but differs from the courses offered at the sixteen institutions listed to such an extent that it is not included with them. The plan has unique features and is one of the most interest-

ing as well as one of the most valuable examples of the application of the cooperative idea. The cooperative part of the program is confined to the year immediately preceding graduation. The work of that year consists of one semester at the Institute devoted to advanced subjects in chemical engineering, and a period of twenty-four weeks devoted to plant study and testing at the various field stations of the school. The field work is essentially of a research nature. Little of it is repeated by successive groups of students. Work at the plants is conducted under the direct supervision of members of the Institute faculty who devote their entire time to this work. While one group of students is at the Institute, the other spends one eight-week period at each of the three field stations. Studies are made of the chemical engineering operations involved in the manufacture of pulp and paper, sugar, heavy chemicals, steel, and other products. The work is done in connection with the regular industrial processes and on full-size apparatus and plant equipment. The student pays for his instruction while at the field stations and receives no pay from the industries. An important aspect of the plan is the benefit which accrues to the industries from the researches of the students. The course is open to graduate students of chemical engineering and leads to the degree Master of Science. Provision is also made whereby seniors of the undergraduate, four-year course may take the work at the field stations.

Location of Institutions.—Of the sixteen institutions offering cooperative courses, all but two are situated in cities of more than 100,000 population, and only one is in a strictly rural community. Twelve of the institutions are in the Middle Atlantic and Central States in which are concentrated most of the industrial activities of the country. Three of the institutions are in Southern States; only one institution is west of the Mississippi. Nearness to industrial activity has evidently been an important factor in instituting the cooperative plan.

Enrollment by Curricula.—The present (1925) distribution of student enrollment in cooperative engineering curricula is given in Table II.

TABLE II

ENROLLMENT OF COOPERATIVE ENGINEERING STUDENTS

	C.E.	E.E.	M.E.	Ch.E.	Others	Total
Cincinnati	248	336	195	123	242	1,144
Northeastern	267	389	198	142	36	1,032
Drexel	125	217	121	35	—	498
Pittsburgh	83	151	104	53	78	469
Marquette	109	166	78	29	65	447
Detroit Univ.	56	123	92	40	89	400
Georgia	48	—	—	—	282	330
M. I. T.		224*		50		274*
No. Carolina	87	93	8	—	—	188
Newark	—	91	42	39	3	175
Akron	55	55	36	—	—	146
N. Y. U.	9	19	40	7	36	111
Evansville	(Distribution not given)					95
So. Methodist	"	"	"			95
Detroit Inst.	—	63	19	5	1	88
Louisville	20	26	6	6	—	58
TOTALS	1,107	1,953	939	529	832	5,550

Courses are now given on the cooperative system in electrical engineering at 15 institutions; in mechanical engineering at 14 institutions; in civil engineering at 13 institutions; in chemical engineering at 11 institutions; in industrial engineering at 2 institutions; and in administrative, aeronautical, architectural, commercial, general, geological, and textile engineering, and also in "arts-engineering," at one institution each. Thus, with the exception of mining † and metallurgical engineering, all of the major engineering curricula are now offered on the cooperative plan.

Introduction of Cooperative Courses.—The years when the several institutions first offered cooperative courses are in-

* Does not include some freshmen who have not designated their course of study.

† Beginning this summer (1926) cooperative work will be elective for freshman and sophomore students in the School of Mines at Pittsburgh.

dicated in Fig. 1. The various features of this diagram are explained by the notes and key accompanying it. For the first twelve years of the history of the cooperative plan, its growth among the engineering colleges was relatively slow. Since the war period, however, the growth has been considerably accelerated, eleven institutions having adopted the plan between the years 1919 and 1925. It has been learned that two other institutions, in addition to those mentioned on page 673, are seriously considering the adoption of the plan in the immediate future.

● Indicates that the institution offered engineering courses prior to the introduction of cooperative courses.
□ Indicates that the institution also offers all-resident engineering courses at present.
* Cooperative courses were abandoned at Lafayette in 1926; at Harvard in 1923.

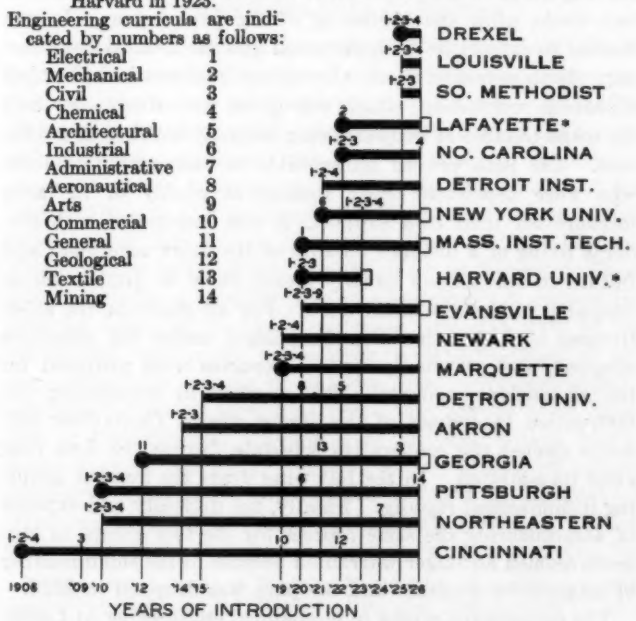


FIG. 1. Introduction of cooperative courses.

Abandonment of Cooperative Courses.—It will be observed from Fig. 1 that Harvard University adopted the cooperative plan in 1920 but discontinued it three years later, and that Lafayette College instituted a cooperative course in mechanical engineering in 1922 and discontinued it in 1926. In both cases the cooperative courses did not develop any considerable demand among the students and were abandoned primarily because of small enrollment. Since these two institutions are the only ones, so far as known, which have dropped cooperative courses after introducing them, the circumstances may be worth mentioning.

The plan at Harvard provided for three bi-monthly periods of industrial employment and four similar periods of classroom instruction between the end of the sophomore year and the beginning of the senior year, with no vacation longer than two weeks after the beginning of the junior year. It was limited to juniors in civil, electrical and mechanical engineering. Both cooperative and all-resident students had identical classroom instruction, which was given intensively; one-half the usual number of subjects being taken at one time at double rate. The plan proved unfavorable to cooperative students who were dependent upon themselves wholly or in large measure for their own support; it was unpopular with students living at a distance because of the short vacations; and failure in one subject usually meant delay in graduation or dropping of the industrial work. For all students, the effectiveness of instruction was diminished under the schedules adopted; and eventually separate courses were provided for the all-resident students. This resulted in triplicating the instruction in courses of the junior year. Thirty-four students elected the cooperative schedule during the first year after its adoption. In the following years the number adopting it diminished rapidly. Finally, the difficulty and expense of administering the same courses for the two groups of students seemed no longer warranted because of the small number of cooperative students and the plan was dropped in 1923.

The cooperative course in mechanical engineering at Lafay-

ette was offered as an option to the all-resident four-year course. It was of five years duration. Cooperative training began at the end of the sophomore year and continued throughout the three remaining years, alternation between college and industry being at intervals of the college term. During the regular college year cooperative students took their places in the regular sections and during the summer special courses were provided for them at the college. The cooperative course did not prove popular with the Lafayette students. Not more than five students elected it in any one year, and the total number graduating during the years of its existence was seven. The last student graduated from the course in 1926 and it was then discontinued.

PART II. ORGANIZATION AND ADMINISTRATION OF COOPERATIVE COURSES

Purposes in Planning Cooperative Programs.—While the purpose common to all cooperative courses is to combine practical experience with scholastic training, there is considerable diversity in the plans which have been instituted in the several colleges for accomplishing this end. A study of cooperative programs shows a considerable range in the details of the work. There is also evidence of differences of purposes and ideals which tabulations of data do not entirely disclose. This has been aptly phrased by Timbie * as follows: "There is no standard cooperative plan of education. A cooperative program takes on the ideals, purposes, and standards of the school and companies cooperating." Modifications of the cooperative plan appear to be more than convenient expedients adopted to suit local conditions; they appear to be traceable to characteristic differences of attitude toward educational matters generally. This condition is not, of course, peculiar to cooperative courses, and is found in the methods employed in many types of educational programs. Attention is specifically called to it, however, since a tendency has

* "Cooperative Course in Electrical Engineering of the Massachusetts Institute of Technology." *Journal of the American Institute of Electrical Engineers*, Vol. 44, No. 6, pp. 613–617.

been observed to regard cooperative courses as a standardized type of curriculum.

While all of the plans for the application of the cooperative principle differ from each other more or less, they appear, in general, to fall into certain principal groups. In one instance the intent is evidently to make the cooperative work virtually an integral part of the curriculum; instruction of the student is continued while he is with the cooperating companies; and his program of experience is mapped out and administered so as to be auxiliary to and coordinate with instruction received in college. He pursues a definitely prescribed course of sequential training, all parts of which are selected with reference to their maximum educational value in the field of his particular curriculum. When the purpose of this type of cooperative program is attained, the periods of industrial experience become virtually an extension of the curriculum beyond the walls of the institution.

In another instance, while the student's industrial experience is in the field of engineering which he has selected, it is precisely the same as he would receive as a regular employee of the company, irrespective of his status as a cooperative student. The purpose here appears to be to place the student strictly on his own responsibility and to acquaint him with industrial requirements just as he would be required to meet them as a regular employee. This does not imply that the institution does not exercise general supervision over the student's industrial work or that it fails to advance him from one type of position to another, but that actual indusrial status and experience are the primary aim.

An example of a third type of program is afforded by that of the School of Chemical Engineering Practice of the Massachusetts Institute of Technology, to which reference has already been made. The intent here is evidently to utilize the facilities of chemical engineering industries for research and testing work on full-size equipment operating under regular industrial conditions. The laboratory work of a portion of the curriculum is thus transferred from the college, where full-scale work is impossible, to industrial establish-

ments where such work can be done. Under this plan, the student remains at all times under the direct supervision of his college instructors, his class work is continued, and he is in no sense an employee of the cooperating companies.

Still another category into which cooperative training may fall may be termed "intermittent education." In such cases, the cooperative plan becomes merely part-time instruction and part-time employment with little relationship between the two.

These differences of purpose, as well as diversity in details of practice, should be borne in mind in examining the data regarding the organization and administration of cooperative programs as set forth in the paragraphs which follow.

Entrance Requirements.—Table III shows requirements for admission to cooperate courses. There is a considerable spread in the number of prescribed units, but not greater than is the case with all-resident courses.

TABLE III

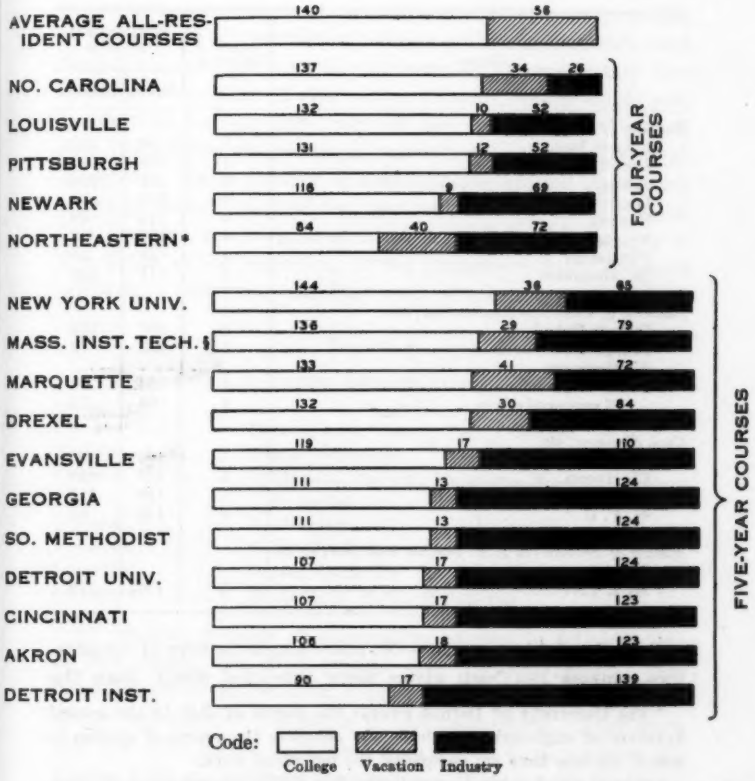
Institution	Total No. of Units	Prescribed	Elective	Mathematics	English	Science	Foreign Language	History	Options	
									Restricted	General
M. I. T.	15	13 or 14	2 or 1	4	3	2	3 or 4	1	2 or 1	
Georgia	15	10½	4½	3½	3	1	2	1	4½	1
N. Y. U.	15	10½	4½	3½	3	1	3		4½	
Akron	15	10	5	3	3	1	2	1	2	3
No. Carolina	15	10	5	3	3	1	2	1		5
Pittsburgh	15	10	5	3	3	1	2	1		5
So. Methodist	15	9½	5½	3½	3	1		2		5½
Drexel	15	9	6	2	3	1	2	1	6	
Louisville	15	9	6	2	3	1	2	1	6	
Detroit Inst.	15	8	7	3	3	1		1	4	3
Detroit Univ.	15	8	7	3	3	1		1		7
Marquette	15	7½	7½	2½	3	1		1	3½	4
Newark	15	7½	7½	2½	3	2			7½	
Evansville	15	7	8	3	3	1		1	2	6
Cincinnati	15	6½	8½	2½	3	-		1	5½	3
Northeastern	15	6	9	2	3	1			9	

Graduation Requirements and Degrees.—The length of cooperative courses leading to the bachelor's degree is either

four or five years, while the length of those leading to the engineer's degree is uniformly five years. The Massachusetts Institute of Technology confers the master's degree upon the completion of a five-year cooperative course, which provides a full quota of the Institute's requirements for the advanced degree, in addition to all of the regular undergraduate subjects of the electrical engineering curriculum, with the exception of some shop work. In the four-year courses, the period spent in school inclusive of examination periods varies from 84 to 137 weeks and the industrial periods total from 20 to 72 weeks. In the five-year courses the school period varies from 90 to 144 weeks and the industrial periods total from 65 to 139 weeks. These data are given in Table IV, and are also depicted graphically in Fig. 2. The usual requirement in institutions having full-time four-year courses is about 140 weeks. Two of the institutions on the cooperative plan confer the degree on the basis of less than two-thirds of this required period of school attendance.

The number of hours per week of classroom attendance required of cooperative students varies considerably in the different institutions, the range being from a minimum of 24 to a maximum of 35. These are actual hours, not credit hours. In total classroom hours required for graduation some of the five-year cooperative courses equal those of four-year all-resident curricula.* The total hours required in the various courses at Cincinnati, for example, equal those at Case School of Applied Science and Ohio State University, which were selected for comparison. In a number of cases, however, the difference in scholastic requirements of cooperative and all-resident courses is considerably greater than any allowance for time devoted to shop courses in the all-resident curricula.

* The scholastic requirements of the five-year cooperative course in electrical engineering at the Massachusetts Institute of Technology exceed the Institute's requirements in all-resident four-year courses. Some of the subjects of the curriculum are taught by members of the regular teaching staff of the Institute to classes of students while they are at the plants of the cooperating companies.



* Students may take either 20 or 72 weeks of industrial work.
§ See footnote (§), Table IV, page 684.

FIG. 2. Distribution of time in cooperative courses.

TABLE IV

LENGTH OF COOPERATIVE COURSES

Degree	Length of course in years	Total weeks required in	
		School	Industry
Bachelor of Science			
Detroit Inst.	5	90	139
Drexel	5	132	84
Georgia	5	111	124
Louisville	4	132	52
Newark	4	116	69
No. Carolina	4	137	26
Pittsburgh	4	131	52
So. Methodist	5	111	124
Bachelor of Electrical Engineering, etc.			
Detroit Univ.*	5	107	124
Marquette †	5	133	72
Northeastern			
1 cooperative yr.	4	124	20
3 cooperative yrs.	4	84	72
Civil Engineer, etc.			
Akron	5	106	123
Cincinnati	5	107	123
Evansville	5	119	110
N. Y. U.	5	144	65
Master of Science (in E.E. together with B.S. as of previous year)			
M. I. T.	5	136‡	79

Periods of Alternation.—No other single feature of cooperative courses has been given more extended study than the

* The University of Detroit awards the degree of B.S. in the several branches of engineering to those who complete the course of studies in school but who have not completed the industrial work.

† Classes which entered prior to October, 1925, pursued curricula leading to the degrees C.E., Ch.E., E.E. and M.E.

‡ While this figure includes all of the time actually spent by the student at the Institute, it does not include the time devoted to regular subjects of the curriculum which are pursued while the student is at the plants of the cooperating companies. This is equivalent to fifteen weeks of resident study at the Institute. The total time devoted to scholastic instruction would be increased from 136 to 151 weeks if this time were added.

periods of alternation between institutions and industry. That the problem has not been solved with complete satisfaction appears certain from the diversity of present practices.

The periods of alternation between college and outside work vary from two weeks to the semester of approximately four months. This plan of alternation extends from a single year to the full four or five years of the curriculum. Table V lists the institutions arranged according to the period of alternation. These periods at some colleges are not rigidly adhered to during part of the year, usually the summer term. Northeastern starts with a 20-week period and changes to five weeks at the beginning of the sophomore year. Newark offers both two-week and four-week alternation plans.

TABLE V

PERIODS OF ALTERNATION BETWEEN COLLEGE AND INDUSTRY

Period.	Institution.
2 weeks	Detroit Inst., Detroit Univ., Newark
3 weeks	Akron, Evansville
4 weeks	Cincinnati, Georgia, Marquette, Newark, Southern Methodist
5 weeks	Northeastern
8 weeks	North Carolina
3 months	Drexel, Louisville
Semester	M. I. T., N. Y. U., Pittsburgh

In general, periods of alternation appear to fall into one of two classes, the short period, and the long period. Administrators of cooperative courses point out that there is a choice between two principles in this connection. They state that the short period is selected with a view to minimizing the effects of discontinuity of instruction. It is thought that with a period of four weeks or less the student is able to take up his class work upon returning from industry at the point where he left off at the end of the previous college period without serious "lost motion." The longer period of a term or semester, on the other hand, is selected because subjects of instruction or major divisions thereof can be completed during a single period at the college and because the student is

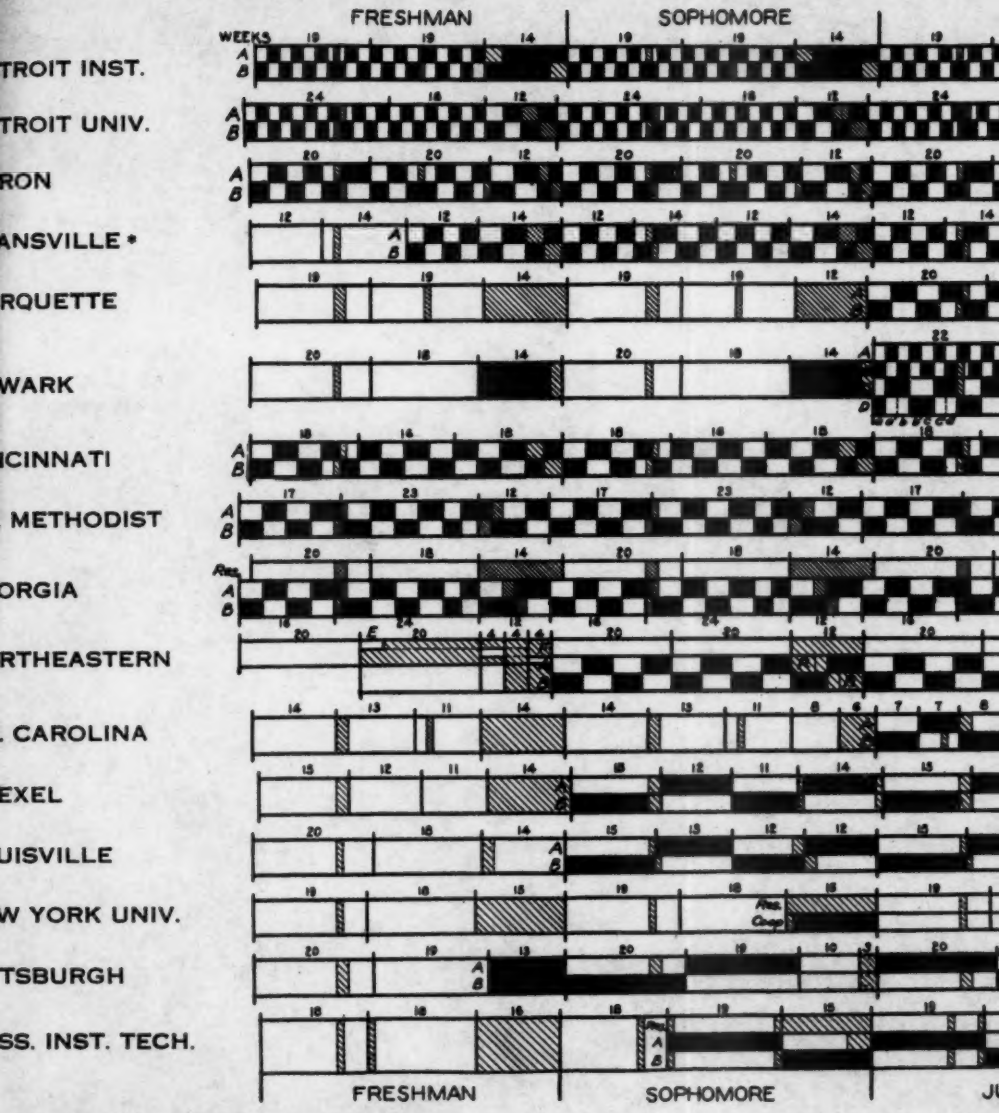
thus enabled more fully to participate in undergraduate activities. There appears to be a division of opinion as to which of these plans is the more advantageous. The tendency, in general, seems to be in the direction of longer periods of alternation. In institutions which offer all-resident as well as cooperative courses in engineering, the selection of the term or semester as the period of alternation offers obvious advantages in simplification of schedules and avoidance of duplication of instruction.

Period at which Industrial Experience Begins.—The period of the curriculum at which industrial experience is first introduced also varies widely. At several of the institutions the student spends all of his time in college for one, two, or even three years before the periods of alternation with industry begin. Some express the belief that the freshman is none too young to begin his experience in the "school of hard knocks." Others believe that a period of orientation to college life of one or more years is highly desirable from the viewpoint of both student and institution. It is felt that such an initial period also serves to relieve the employers of a large turn-over of personnel. Practices in this matter are shown graphically by Fig. 3.

Cooperative Schedules.—The cooperative schedules for the full course at the sixteen colleges are shown in detail in Fig. 3. Each diagram depicts the commencement and termination of the interval of industrial affiliation and also the periods of alternation between college and industry. While these schedules have been made with care in accordance with all the information at hand, there may be some minor inaccuracies in allowing for vacations and examinations.

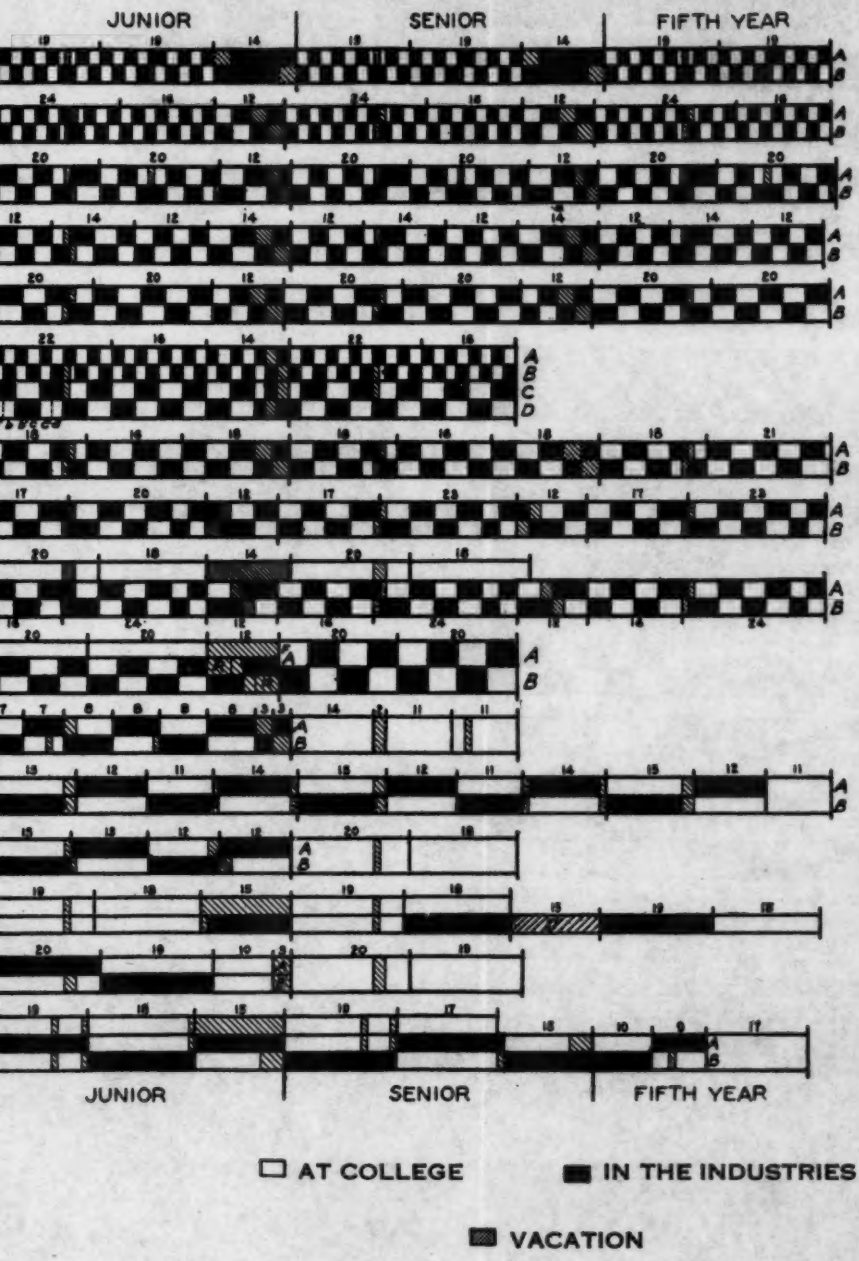
Some features of the diagram and of the operating details of cooperative programs are explained in the following notes:

In the schedules for Georgia, M. I. T., and N. Y. U. in Fig. 3, the upper portion shows the school periods for the four-year all-resident courses for purposes of comparison. At Evansville, students having two years' credit in liberal arts subjects may transfer to the arts-engineering course requiring either four years' full time, or 6 quarters full time plus 10 quarters of cooperative or "half-time," for the degree of B.S. in Arts-Engineering. Students at Cincinnati pursuing the course in geological engineering alternate at about



B signify the two alternating groups of students.
D signify groups of students alternating at four-week intervals.
This four-week term is really spread over a ten-week period.
Full-time students.
Review courses of four-weeks duration, required only of conditioned students.
The student is expected to spend twelve weeks of this period in industry.
Unassigned term which may be used to complete any unfinished college work.
Also offers a course leading to the degree Bachelor of Science in Arts-Engineering which may be taken on all-resident or cooperative plan.
—Resident students.

FIG. 3. Alternation periods in cooperative



cooperative schedules.

The schedule of N. Y. U. illustrated in Fig. 4 for both the all-resident and cooperative engineering courses presents a unique feature in that no instruction whatever is duplicated and no regular instruction is given during the summer. The school terms are numbered from 1 to 8 and the four industrial periods are numbered from I to IV. For the cooperative student there is a gap of exactly one year between the seventh and eighth terms in college, two-thirds of which period is devoted to industrial work and the remainder is unassigned. The unassigned term, marked U, may be used by the senior for completing unfinished school work, or for taking courses in the Summer School of the University, or for additional industrial experience. If the student is not paired with a junior, he may interchange terms III and U in order to repeat second semester subjects, or interchange terms IV and U to repeat first semester subjects. Transition from all-resident courses to cooperative on the foregoing plan could be made by an institution with little inconvenience and without involving a change in its teaching schedule.

Coordination.—The method by which the coordination between college work and industrial experience is accomplished is one of the important features of the cooperative plan. In most cases direction of the student's industrial employment is in charge of one or more individuals, known as coordinators, directors of industrial cooperation, and the like. In several institutions, such as Cincinnati, for example, there is a complete staff of coordinators which reports to the dean and acts independently of the teaching faculty. In others, certain members of the regular teaching staff devote part of their time to supervision of the students' industrial work. One institution reports that it has no coordinator and no activity corresponding to the coordinating function. The number of students per coordinator varies from 25 to 170.

Coordinators are usually given faculty rank, ranging from Instructor to Associate Professor. In some instances coordinators are not given faculty rank but are designated Director of Industrial Cooperation and the like. Practically all of the coordinators are engineering graduates; most of them have had industrial experience; a goodly proportion are Cincinnati graduates.

The work of the coordinator includes the following:

(*a*) Establishing relations with firms and arranging for positions.

(*b*) Keeping these positions filled.

(*c*) Shifting students about so that their training shall be progressive.
(*d*) Keeping records of the students' progress.
(*e*) Maintaining sufficiently close contacts with students and firms so that troubles can be adjusted or foreseen and prevented.
(*f*) Acting as advisers to the students and assisting them to get the most out of their industrial experience.

There is considerable range in the matter of the closeness of the supervision of the student's industrial work. In most cases the coordinator visits the various cooperating firms at intervals and interviews both the student and his superior. In many cases the student is required to submit written reports during or upon completion of each period in industry. In some cases reports are submitted as often as once a week; in others, once each working period, even though it be twelve weeks long. Weekly or bi-weekly reports are often mentioned. Reports are submitted to the coordinator or to the head of the student's department in college, and in some cases are also criticized by members of the Department of English.

Contact of students and coordinators is effected in one or more of several ways, of which the following are illustrations:

(*a*) Personal interviews with individual students during both school and industrial periods.
(*b*) Meetings of the coordinator with entire classes or sections. Such meetings are scheduled as is any classroom exercise and are often called "Class in Coordination."

Where frequent individual personal contacts are possible, the intent seems to be to maintain an approximation to the idea of laboratory instruction; where the contacts are less frequent or less personal, the intent apparently is to initiate the student into the state of mind of the worker and to put him completely on his own responsibility. On the other hand, it costs less to conduct the work of coordination by classes than it does by individuals.

How Closely are College Work and Industrial Experience Coordinated?—A question frequently asked regarding cooperative courses is—"To what extent is it possible to correlate the student's industrial experience with his college studies?" Statements received from the institutions indicate that there is no great difficulty in obtaining broad correlation with the student's major field of study, *i.e.*, employment may readily be arranged along the general lines of the several curricula.

There is, however, little or no attempt at what some term "day by day coordination" between the industrial work of a given period and the subjects studied in the preceding school period. A number of institutions state that this often occurs accidentally. In several institutions opportunities to bring about this type of coordination (as, for example, work in a field party with simultaneous classroom study of surveying) are utilized as they occur, but no attempt is made to provide it in all cases or throughout the curriculum. In fact, the variety of studies pursued by engineering students would make this impossible.

Endeavor to provide for correlation of college and industrial work is also reflected in some cases in the arrangement of the curriculum itself, as, for example, the placing of elementary surveying in the freshman year for civil engineers, elementary electrical engineering in the freshman year for electrical engineers, and the like.

Rating of Industrial Work.—The work of the student in industry is usually rated or evaluated according to some particular system. In some institutions this rating is dispensed with, on the assumption, apparently, that the employer's permission to remain on the work is sufficient evidence of merit. The majority of schools, however, use one or more of the following methods:

(*a*) Conferences by the coordinator with the employer or his representative, preferably with the student's immediate superior. The advantage of this system is that a student is rated by a single experienced individual upon the basis of evidence and opinion gathered by him.

(*b*) Reports by employers' foremen on forms supplied by the

school, made up in such a way that check marks in various spaces designate the student's rating. If thoughtfully and carefully made, these ratings are excellent, but there is evidence that they are often done perfunctorily. Owing to the fact that there are often as many foremen supplying ratings as there are students to be rated, the results are likely to be very diverse.

(*c*) Reports submitted by the students themselves to the coordinator. If these reports are carefully rated, they doubtless furnish a good indication of the student's work and progress.

(*d*) Examinations on return to college. Apparently, only one school uses this method.

The forms used in methods (*a*) and (*b*) designate a number of personal qualities and points which tend to evidence the grade of the student's work; such, for example, as reliability, initiative, self-reliance, application, interest, speed, and the like. Opposite each of these are placed spaces for a five-point or a three-point rating scale with descriptive adjectives ranging from high merit to failure.

These ratings form a part of the records relating to each student. They are filed for reference as are ordinary scholastic or personnel records, and they also serve to aid in properly placing the student after graduation.

Earnings of Cooperative Students.—Whether the matter of earnings by the student during his course is or is not looked upon as a matter of major importance, it is certainly worthy of consideration. Studies made by other committees of the Society indicate that engineering students, generally speaking, come from homes of modest means and that considerable numbers of them earn all or a substantial part of their college expenses through employment during vacations and term time. The cooperative plan offers a means toward the solution of the financial problem of many students.

It is to be noted that the colleges endeavor to prevent undue emphasis upon this matter by stating that earnings from in-

dustrial work are entirely subordinate to the educational aspects of the cooperative plan.

During the early part of the curriculum, rates of pay are seldom more than sufficient to meet the student's living expenses while he is working in the industries. Toward the end of his course, however, he is earning at higher rates and can no doubt lay aside some money toward payment of his college expenses. Figures on earnings supplied by the colleges give ranges between the following limits (earnings are given in dollars per week):

	1st Year	2d Year	3d Year	4th Year	5th Year
Lowest	15.50	20.00	22.00	25.00	25.00
Highest	24.00	30.00	34.00	40.00	50.00

If it is desired to compute the student's total earnings for a year, it must be remembered that he works but half the year; if earnings for the entire school period are to be computed, it must be remembered that cooperative training does not always extend over the full course.

The lowest figures are from a southern institution, the highest are from an institution in a locality where wages are generally considered high. To give a fair comparison, living costs should be included.

Relations between Colleges and Industrial Firms.—Affiliations with industrial firms appear to be quite generally based upon the following ideas:

1. Firms of good repute should be selected and preference given to firms which are large enough to afford a sufficient variety of experience, and centralized enough to have a unity of policy.

2. Preference should be given to plants situated near the college, especially if alternation periods are short.

3. In seeking affiliation with a concern, the highest possible officers should be interested in the plan and they should be led to endorse it heartily as a method of training men for their organization.

4. Firms should be willing to cooperate in giving students

opportunities to obtain well-rounded experience under actual working conditions.

5. The organization of the firms should be such that cooperative students are easily accessible to the coordinator for interviewing.

6. Each firm should have some officer to act as representative for its students, as well as to look after the interests of the firm.

7. While the character of experience gained by the students is more important than the salary received, it should not be forgotten that the latter may be a determining factor with some students.

For the most part the cooperating industries do not maintain specific organizations for the purpose of training cooperative students, though there are important exceptions. Several large corporations having educational departments or maintaining cadet systems, apprentice systems, etc., employ the organizations devoted to such matters to deal with the cooperative students at their plants. In the smaller firms entire reliance seems to be placed on the coordinator to look after his students, to see that they are shifted sufficiently to get new experience, to obtain raises of pay for them, and so forth.

Selection of Students for Cooperative Work.—The selection of students for work in the various concerns is usually made by both the college and the firm. The coordinator usually takes the initiative and recommends students to the cooperating concerns. Often this is all that is necessary to secure employment up to the limit of numbers agreed upon by the firm, although some firms make a selection from the candidates so recommended. Not all of the students at M. I. T. who desire to take the cooperative course in electrical engineering are selected by its five affiliated industries because they limit the number of men taken on to sixty-six per year. Through verbal agreements with the Institute, these concerns virtually guarantee employment for three years to the following numbers of students from each class: General Electric Company, thirty; Bell System, twenty; Stone & Webster,

ten; Boston Edison Company, four; and Boston Elevated Railway, two. These men are expected to stay with the one firm for the entire course; in fact, many retain employment with their companies after graduation. Forty-six per cent of the M. I. T. cooperative graduates are still with the cooperating companies.

The majority of institutions report that it is preferable for a student to take all of his industrial work with one concern, provided this firm has sufficiently varied work to give him a wide range of experience. If cooperation is undertaken with the smaller firms because of the value of certain lines of experience which they offer, it is definitely understood that the students will remain for limited periods only. Some firms require a contract (after a short trial period) for a definite time, one and two year periods being mentioned. One school reports that it will not permit any such contracts.

Where changes from firm to firm are made, such changes nearly always require the permission of the coordinator, and often of the dean and department head in addition. In one institution the consent of the firm and the real reason for leaving are required from the student, presumably in addition to the above. Changes would naturally take place at the regular period of alternation, but a student might be required to serve out a period of notice to the firm.

Status of the Student in Industry.—While engaged in industrial work, students are placed on the same footing as the regular employees. So far as can be learned, there has been no general opposition to the employment of engineering students on the part of organized labor. Where strikes have occurred the students have been withdrawn and placed with other companies.

Care obviously must be exercised by the colleges in selecting their students so that no serious difficulty will be experienced in finding positions for them because of racial or physical limitations. Several colleges state that all students likely to meet with such difficulties are advised before entering the cooperative courses as to the preferences of industries, but that no restrictions are made by the school.

Since industrial depressions may interfere with cooperative work in industry, it may be well to mention that at one institution a committee makes periodic surveys of the economic conditions of the affiliated concerns, and students are withdrawn in anticipation of an industrial retrenchment and are placed elsewhere.

Elimination of College Shops.—The elimination of woodworking and machine shops, and of the courses in shopwork, is often mentioned as one of the benefits accruing to the college when operating on the cooperative plan. Eleven of the schools report to this effect, but a few make reservations. One omits woodshop equipment and the subject of woodwork, giving instruction in other shop courses; another omits no shop courses. Three institutions made no reply to this question.

Four institutions omit "considerable surveying," one "considerable drafting," and one "specialized machine design." Two institutions state that most laboratory equipment can be reduced in amount, though they list no reduction in laboratory subjects.

Numbers of Students and Teachers.—Obviously, with a given physical plant a greater number of students can be accommodated under the cooperative plan, but reflection will show that the number of students per teacher cannot be increased without increasing the load of teaching per member of the staff. In the majority of cases, particularly when the period of alternation is other than the academic term or semester, the engineering teaching staff is on duty throughout the year, except for one or more vacations, these usually being one or two weeks at Christmas, and a summer vacation varying from a "catch as catch can" period of two weeks to a more generous one of four to five weeks; these are naturally made to correspond with the vacations of the students. With the short period of alternation, where it is usually considered essential to keep the industrial positions always filled, vacations have to be taken at different times by different persons. With the longer periods, especially where they correspond to

the semester, it is possible to maintain the customary collegiate vacations—Christmas, spring, and summer.

Costs.—Little information is at hand in regard to the cost of instruction at cooperative schools. Studies previously made by other investigators show such a wide variation in the cost per student per year at many all-resident institutions that unqualified comparisons are misleading. Nevertheless, a comparison in costs between the Case School of Applied Science and the University of Cincinnati will be of interest, since both are in the same general locality, both have complete teaching staffs under the direction of the Dean of Engineering, and both have nearly the same salary scale. At Case, with 580 students and 57 instructors, the cost per student was $560 per year in 1923–24 (including all budget items, but excluding interest and depreciation), while at Cincinnati, with 1,136 students and 53 instructors, the cost on the same basis was $340 per student in 1924–25.

PART III. APPRAISAL OF VALUE OF THE COOPERATIVE METHOD

The really fundamental question for consideration in this report relates to the soundness and value of the cooperative plan and its advantages both on an absolute basis and in comparison with the older "regular" engineering curriculum. It would be extremely desirable in this report to formulate a definite answer to this question, or at least to determine definitely the peculiar merits of the cooperative plan and its particular and proper place in the general scheme of engineering education. It must be stated at the outset that no definite conclusion warranting a concrete, unequivocal statement has been reached. It is probably inevitable that such should have been the outcome. Fundamental problems of education are so complex and the results of educational processes so intangible that it is often impossible to reduce them to the basis of concrete analysis and objective valuation.

Probably the best approach to a judgment as to the value of cooperative engineering training is to cite such facts as are available; to set down the opinions, pro and con, in the

matter; impartially to discuss both facts and opinions; and to leave the reader free to draw his own conclusions. If experience in such matters is any guide, in many cases he will then proceed to do this in accordance with his preconceived opinions or convictions arrived at by reason of his training, associations, or general viewpoint on educational matters.

A. Analysis of Available Facts

Nature and Source of the Data.—As intimated above, the element of objectivity would be very valuable in connection with such a study as the present. It is extremely difficult, however, to gather a body of data which is both sufficiently comprehensive and sufficiently accurate to furnish a basis of judgment. It would be even more difficult to conduct any "controlled" experiment or test which would be of real value. In considering this problem it was concluded that possibly some evidence of value might be extracted from information regarding the careers, advancement, earnings and other matters relating to graduates obtained in connection with another study.* Accordingly, data supplied by graduates of two institutions, one offering cooperative and the other all-resident curricula, were analyzed and compared. These two institutions, while differing in the types of programs offered, are alike as to environment, number of students enrolled (if the number of cooperative students attending classes at one time be taken as the basis of comparison), size and general quality of faculty, and quantitative scholastic requirements for graduation. Both are institutions of excellent standing. One institution exercises complete control over its admission requirements. The other is obliged to admit all graduates of the high schools of its city, from which source approximately four-tenths of its entering students are drawn. Tests of training and aptitude † given to freshmen of the two institutions indicated no marked differences in the ability and

* See Bulletin No. 3 of this series—"A Study of Engineering Graduates and Former Students, Non-Graduates."

† The Iowa Placement Examinations were given to freshman classes in the two institutions in the fall of 1925.

preparation of the student bodies. Apparently both institutions attract students of good ability at present. It was not possible, however, to form any judgment as to this matter in the past. These two colleges will be designated "A" and "B" in the tabulations which follow.

It was hoped that the results of this analysis might serve to measure the results of the two types of programs. It will be observed from the condensed summary of results which follows that the findings are largely inconclusive. They show no marked differences between the two groups of graduates. This may, of course, be due to limitations of the method employed, or to other factors.

Among other points covered by the comparison are: The number of positions occupied by graduates in a given period after graduation; the relationship of fields of work of graduates to courses pursued in college; types of positions occupied —administrative, supervisory, technical, and so forth; and earnings and rates of advancement therein. The reactions and opinions of the graduates on questions relating to the quality of their instruction in college, satisfaction or dissatisfaction with their present positions and prospects, studying done since graduation, and other matters, were also studied.

Number of Positions Occupied.—Graduates of the all-resident courses showed fewer changes of position in the first two or three years after leaving college than did the graduates of cooperative courses. This was striking among graduates of the class of 1922. The tabulation which follows shows the percentages of the class holding one, two, or three distinctly different positions during the first thirty months after graduation.

	Cooperative Graduates Institution A	All-resident Graduates Institution B
One position	26.6%	50.0%
Two positions	46.7	25.8
Three positions	26.7	24.2

Among members of the class of 1923, cooperative graduates showed slightly greater stability during the first eighteen

months after leaving college. The reverse was true of graduates of the class of 1924.

Relationship of Fields of Work to College Courses.—In making this analysis, the fields of work of graduates were classified in four divisions: (1) the *same* field as that of the student's course in college, (2) a *closely associated* field, (3) *"other"* engineering fields; *i.e.*, those not closely related to courses pursued in college, and (4) *non-engineering* fields. The composite results for graduates of all courses of the two institutions show almost identical proportions in these four divisions, the figures being as follows:

	Cooperative Graduates Institution A	All-resident Graduates Institution B
Same field	52.9%	48.0%
Closely associated field	10.1	10.6
"Other" engineering	24.0	25.4
Non-engineering	13.0	16.0

A more detailed analysis shows, however, that a considerably larger proportion of cooperative graduates of electrical and mechanical engineering remains within the same field as their college course than is the case with all-resident graduates. The reverse is true of chemical and civil engineering graduates. These differences were especially apparent among the younger graduates. There may be some significance in these results. It is possible that they indicate greater adaptability of the cooperative graduate to the field of operating and administrative duties connected with manufacturing industries which is entered by electrical and mechanical engineering graduates to a very considerable extent.* The evidence quoted is probably not sufficient in itself to warrant such a general conclusion, though it appears to point in that direction.

Types of Positions Occupied.—The division of occupations

* For statistical evidence on this point see Bulletin No. 8 of this series —"A Study of a Group of Electrical Engineering Graduates," pages 2 and 3.

of graduates among the several functional, as distinguished from the technical, types of activity is shown below.

Types of Positions	Cooperative Graduates Institution A		All-resident Graduates Institution B	
	Recent Classes	Older Classes	Recent Classes	Older Classes
Primarily administrative—owner, proprietor, executive, administrative, supervisory, etc.	27.7%	58.1%	24.3%	60.0%
Primarily technical—design, estimating, drafting, testing, operation and maintenance, etc.	55.9	19.6	60.6	24.6
Research and teaching	11.5	16.1	12.5	13.4
Miscellaneous	4.9	6.3	2.6	2.0

The figures for the two institutions exhibit a striking similarity.

Earnings.—Statistics on the earnings of the graduates of the two institutions are interesting. The following table gives the median * earnings, as of approximately January 1, 1925, of graduates having the numbers of years of experience indicated. The proportions of graduates reporting were from 35 to 40 per cent and were practically the same for the two institutions. The table affords not only a comparison of earnings of graduates of the two institutions, but also a comparison with the earnings of a large group of graduates of a number of institutions throughout the country.

	Cooperative Graduates Institution A	All-resident Graduates Institution B	Graduates of many Institutions†
Immediately after graduation	$1,740	$1,500	$1,476
One year after graduation	2,060	1,800	1,800
Two years after graduation	2,400	1,990	2,100
Three years after graduation	2,720	2,142	2,400
Five years after graduation	3,120	3,000	2,860
Ten years after graduation	4,275	4,350	4,000

The following tabulations show the progressive advancement in median earnings of members of two particular classes.

* The median is the middle number and has as many numbers larger than itself as it has numbers smaller than itself.

† These figures are taken from Bulletin No. 3 of this series, pages 7, 35 and 36.

	Years After Graduation						Number Reporting
	0	1	2	3	5	10	
Class of 1919							
Cooperative	$1,750	2,000	2,400	2,600	3,000		24
All-resident	$1,200	1,740	2,000	2,142	3,000		24
Class of 1914							
Cooperative	$ 900	1,150	1,465	1,860	2,660	4,240	24*
All-resident	$ 780	936	1,200	1,800	2,400	4,350	29

It must be remembered in comparing the earnings of graduates of these institutions that the cooperative course is one year longer than the all-resident course, five years instead of four, and consequently that the cooperative graduate is one year older than the all-resident graduate of the same number of years of experience. Furthermore the cooperative student has received industrial training during his undergraduate years of as great duration as, or of greater duration than, that received by the all-resident graduate in his first year after graduation. In fairness, therefore, figures for the same number of years of experience should not be compared. If graduates are to be considered on the basis of equal ages and approximately equal experience, earnings of the graduates of the cooperative course immediately after leaving college should be compared with those of all-resident graduates one year after graduation, those of cooperative graduates of one year's experience with those of all-resident graduates of two years' experience, and so forth. If this is done, it will be observed that the two groups earned almost identical amounts in their early years. The inclined lines in the tabulations indicates the figures which should be compared on this basis.

It should be clearly understood that these figures and the discussion of them are based upon a limited number of cases and are therefore uncertain. The percentages of individuals who responded to the request for information are very nearly the same in the two cases, and the institutions probably afford as valid a comparison as any which could be selected. The data supplied by the larger group of graduates of many institutions also serve as a check. Nevertheless, the results ought to be taken merely as tentative.

* Classes of 1913, 1914 and 1915 were included in order to obtain a larger number of cases. Figures for the three classes are quite similar.

Replies of Graduates to Other Questions.—In their replies to questions as to the quality of instruction received in college, its relationship to practical needs after graduation, attitude toward positions and prospects, liking for engineering as a vocation, and other similar questions, the graduates of the two institutions indicated little or no difference of view. Both groups appear to think highly of their college courses and the preparation afforded them for careers in engineering.

Limitations of Statistical Evidence.—It is perfectly clear, of course, that the evaluation of cooperative courses can not rest entirely on evidence which can be expressed in statistical form. One of the best indices of the value of an educational program is the degree of responsibility pertaining to positions occupied by its graduates. It is practically impossible, however, to reduce such information to valid statistical statement. It is also evident in the present instance that the period which has elapsed since the establishment of cooperative courses has been so short that the data relating to graduates are inclusive. Relatively few graduates of cooperative courses have had as much as ten years of experience at the present time. Probably at least twenty years and possibly more will be needed to indicate the position which the cooperative graduate will achieve in the field of engineering.

B. Analysis of Opinions Relative to Cooperative Training

Source of the Opinions.—A second aid to the effort to appraise the cooperative system, which naturally suggests itself, is an analysis of the opinions of those competent to express themselves. In the present study, opinions were sought only from those whose experience, position, and opportunity for observation were such as to qualify them to express themselves. At the same time the effort was made to select individuals representing different points of view in the matter. Questionnaires were sent by the committee, to administrators, teachers, and coordinators in institutions offering cooperative courses, and to men in industry who have had experience with cooperative students and graduates. Many of these

individuals are themselves graduates of cooperative courses. As a whole, the group is made up largely of advocates of the cooperative plan, who might be expected to give *ex-parte* opinions. It proved to be difficult to obtain the views of those likely to hold a more impartial viewpoint as completely or systematically as was needed to give a balanced summary. As is usual in controversial matters, those who are strong advocates of a plan or proposal have usually formulated their arguments and opinions more concretely than those having a less direct and vital interest in it. Nevertheless, a considerable body of opinion, both pro and con, has been gathered by means of the questionnaires. This has been supplemented by views expressed in conferences and by statements appearing in print.

The summary which follows is an attempt to arrange these opinions in orderly fashion. Opposite each argument advanced either for or against the cooperative system a counter argument or rebuttal has been set down. These arguments were gleaned from the results of the canvass mentioned above and are not the views of the committee or the Staff.

Advantages to the Student—Educational and Vocational

For the Plan	*Against the Plan*
(*Statements of Advocates*)	(*Statements of Opponents*)
The cooperative plan provides systematically coordinated instruction in principles, and practical training in their application. The relationship of theory to practice is shown. The student is trained in the use of knowledge. Respect for and interest in the principle is thereby increased and the learning process is accelerated. Many details and methods of practice which cannot be taught adequately in the classroom are learned through observation in industry.	These claims are based largely upon an assumed correlation of college and industrial work which is more of an ideal than an actuality. The types of positions occupied by cooperative students, particularly in their early years, when much of the basic theory of science and engineering is taught, are not such as to make possible any demonstration of the application of principles learned in college.

Periods of practical industrial experience develop the student's personality and strengthen his character. His courage, resourcefulness and stamina are tested; his sense of responsibility is brought into play; self-confidence and initiative are developed. Industrial experience acts as a much needed steadying influence. The student learns to see things in their true light and to value them accordingly; in particular he is more likely to appreciate the value of his education.

Practical work is the best form of educational and vocational guidance. The student acquires a knowledge of one or more lines of work through first hand experience. He is thus able to choose his field of work and a particular position in it with some discrimination. Transition from college to practical life is prepared for and is easily made upon graduation.

The inference is that the ordinary college course does not accomplish these ends as well. This is not proved and probably cannot be demonstrated objectively. It must be remembered that the great majority of engineering students work during their vacations and are thus tested in the manner indicated. There may be some basis, however, for the claim that the cooperative course provides a much better opportunity, under systematic guidance, for the development of traits of character not brought into play in the college environment. If so, it constitutes one of the greatest advantages of the cooperative system.

Answers to these claims fall into two classes. One group concedes that the cooperative plan appears to possess merits in providing a means of valid vocational guidance. They point out, however, that colleges offering all-resident courses are recognizing the need of practical guidance of students and are providing for it through orientation courses, lectures and other means. The other group is inclined to believe that the colleges have already gone too far in a paternalistic attitude and that both students and graduates should be thrown very much more on their own resources, particularly in choosing fields of work and in obtaining employment. They are inclined to believe that the cooperative plan accentuates "coddling," which they deplore.

Through intimate contacts in industry the student obtains an insight into labor problems and a knowledge of the reactions and psychology of the working man. He thus learns to appreciate and respect the problems of the men he will subsequently direct. The best time for the young man to acquire the proper point of view in these matters is while he is still young. The graduate is not likely to have either the opportunity or much inclination to do so.	It is generally admitted that this is probably a valuable feature of the cooperative plan.
The student learns to get along with others, to work under supervision, to follow instructions and to abide by the decisions of his superiors. Thus, from the discipline of obeying instructions, he learns to direct the work of others. In general, he is brought to a proper appreciation of the human factor in practical affairs.	This also is an advantage of the cooperative plan for which no adequate denial is found among the opinions collected. This factor would appear to be important in preparing students for the operating duties of industry.
The student learns business organization and procedure through actual observation and practice. He is brought face to face with the economic as well as with the technical side of engineering. The all-resident student, on the contrary, has little or no opportunity to learn business organization and procedure since there is little time available for such instruction in the undergraduate curriculum. Furthermore, it is very difficult, if not impossible, to teach such matters in the classroom.	Two counter arguments are given to these statements: First, that the types of positions occupied by cooperative students are of such a subordinate nature that little or no opportunity is afforded to learn business principles and methods. Second, that the graduate of the all-resident course learns these things during his introductory period in industry quite as well as he would under the cooperative plan; in fact, being more mature, he has a better appreciation of their importance.
The student observes and learns up-to-date shop practices and engineering methods.	Possibly he does. Does he, however, learn fundamental principles as well?

Advantages to the Student—Financial

The student is able to earn a large part of his expenses. Many young men are thus enabled to obtain an engineering education who would not otherwise be able to do so.	The great majority of engineering students work during their vacations. Rates of pay of cooperative students, particularly in their early positions, are small. Furthermore, industrial experience begins, in a majority of institutions, one or more years after admission. It is doubtful if, on the whole the cooperative student is any better off financially than is the all-resident student who works during the vacations. An important aspect of this matter which must not be overlooked is that graduation of the cooperative student is deferred one year (cooperative courses are usually of five years duration, all-resident courses four years). The advent of the cooperative student to full-fledged employment and financial independence is therefore postponed, a serious matter in many individual cases and undesirable in general.
Salaries of cooperative graduates exceed those of all-resident graduates.	This claim is not backed by evidence. (Data presented in this report, see pages 700 to 702 incl., do not substantiate the claim. It is true that the figures show greater earnings of the cooperative graduate immediately after leaving college and for a few years thereafter, but if equal age be made the basis of comparison, the graduates of the two courses are on an equal footing. The evidence presented is not conclusive, however, and until adequate information is available, claims of the superior earning ability of one group or the other ought not to be made.—Ed.)

The student establishes a demand for his services. It is easier to place cooperative than all-resident graduates.

Again, the facts do not substantiate the contention. The demand for graduates of all-resident courses exceeds the supply. Industries which recruit technically trained personnel systematically do not distinguish between graduates of the two types of courses.

The period of apprenticeship of the graduate in industry is reduced and his promotion is more rapid.

An answer to this assertion is furnished by the statement of the Director of Personnel of a firm which employs large numbers of graduates and has systematically recruited and trained them for years. He stated that the all-resident graduate is as far along in his company's organization one year after leaving college as is the cooperative graduate upon leaving college, or farther—the two men then being of the same age. This is true, however, only if the cooperative graduate has spent his industrial periods with the company in question. If industrial experience was acquired with another company, the cooperative graduate starts on exactly the same basis as the all-resident graduate. Thereafter there is no discernible difference in their rate of advancement.

Advantages to the Institution and Faculty

With given facilities and staff, more students can be accommodated. The cost per student is thus reduced. The resources of the institution are made available to a larger number. Certain shops and laboratories can be eliminated or reduced, thus further reducing the cost.

If students take the same number of hours of instruction in sections of the same size and if the teachers carry the same teaching loads, the cost of instruction will not be different in the two cases. If it is different, the student either takes less work or the teacher does more without corresponding increase of compensation. From ob-

servation, the latter seems to be the case. Overhead expenses of administration, upkeep of buildings, and the like are less in the cooperative system but this saving is offset by the cost of maintaining a corps of coordinators. The investment per student in buildings and equipment however is reduced. This is a matter of great economic importance.

The cooperative student returning from his periods of industrial experience is more discerning and rationally critical of the work of his instructors. The faculty is, therefore, forced to keep abreast of current practices and does not get into a rut. The cooperative student, through his greater appreciation of the value of his education, is more of a challenge and an inspiration to his teachers.

On the other hand, the faculty is under the burden of repeating instruction to alternating sections of a class. This increases the monotony of instruction and tends to accentuate the tendency to get into a rut. Furthermore, the staff is engaged during eleven months of the year (in most colleges operating on the cooperative plan). There is less opportunity for independent study and research and the teacher tends to become a purely routine task-bearer. The statements of teachers indicate that the intensive nature of cooperative courses, as practiced, places increased burdens on the faculty and that this is one of the serious disadvantages of the plan.

Close relationships are established between the institutions and the industries. A basis of mutual appreciation of educational and industrial problems is thus afforded which is of great benefit to the college.

Equally intimate and valuable contacts can be maintained through other means; in particular through members of the teaching staff who serve industry directly in consulting and advisory capacities and through research carried out for the benefit of industry. Such activities are inhibited under the pressure of the cooperative system.

Advantages to Industry

An opportunity is afforded to try out the students, to observe their ability and traits of character and to choose those of greatest promise for permanent employment. The students are more easily assimilated into the organization and are inculcated with a spirit of loyalty to it.

This may be true, but is it always for the student's best interest? Is there not danger that the organization may exploit the students to its own advantage?

Cooperative students may be placed with small industrial concerns which do not see the necessity or advantage of employing engineering graduates. Such firms are educated to the value of technically trained personnel and of scientific methods, and are thus included among those benefiting from the results of engineering education.

Why need this result depend upon the cooperative plan? Is not the same thing going on steadily throughout all industry whether or not the cooperative method furnishes the entering wedge?

Industries have found it more difficult to obtain suitable personnel for the operation of plants and processes than they have to obtain competent designers. The cooperative plan furnishes men having a background of experience and point of view which is indispensable in the line of operating duties. Engineering graduates will be required more and more in the future for work of this character.

If this be granted, is it not possible that the development of this side of the student will make him less competent on the more strictly technical side of his work?

Disadvantages to the Student

Against the Plan (*Statements of Opponents*)	*For the Plan* (*Statements of Advocates*)
The length of the college course is increased and the advent of the student to productive employment is deferred.	On the other hand, the student both produces and earns while he is in college, thus offsetting any disadvantage of deferred graduation. Furthermore, the length of

	the cooperative course is not greater than that of all-resident courses in several institutions.
Cooperative courses operate under higher pressure. Students carry a larger load of classroom instruction. There is an undesirable "high degree of concentration in the curriculum" and insufficient time for non-technical subjects. There is less time for study and reflection and for the process of "unconscious assimilation."	These objections are not inherent in the cooperative system but only in the way it is conducted in some institutions. They can be removed under proper handling just as readily as in the all-resident system.
Intermittent instruction causes undesirable breaks in class work. Continuity of the learning process, which is indispensable to proper educational results, is impossible. There is loss of time due to interruption of instruction and the student must readjust himself to college work upon each return from industry.	Teachers of cooperative courses testify that the fear upon which this contention is based is groundless and that alternation of classroom and industrial work affords a rest from the steady grind of college which results in greater mental activity and increased efficiency.
The cooperative plan interferes with participation in college activities which are a valuable phase of college life; in fact, many of the desirable activities cannot be carried on at all.	On the other hand, the student forms contacts outside of college and his interests are thereby broadened. Furthermore, administrative arrangements may be made so that participation in athletics is not interfered with.
There is danger that the student may become saturated with the idea of commercial success to the exclusion of broader cultural interests.	This is pure nonsense.
The eleven-month year of the cooperative course provides very little time for vacations and no single vacation of any considerable length. This is especially undesirable for students whose homes	This would affect an insignificant number of students, since engineering colleges draw their students from a comparatively small radius (for statistics on this matter see Bulletin No. 1 of this series, pages

are at a distance. During the entire five years it would not be possible for them to be at home more that a few days and only then at great expense in proportion to the time spent with their families. This is a condition to which students and parents alike can justly object.

5, 6 and 29). Students seriously affected by this phase of the plan need not enroll in it. It is not contended, except by a very few, that the cooperative plan should be established in all colleges or required of all students.

The cooperative plan does not afford sufficient opportunity for the development of the student's social side. Contacts with fellow students, particularly those in courses other than engineering, and participation in social activities are, in general, one of the valuable aspects of college years. They serve to give the student poise in his social contacts and to prepare him for that side of life after graduation. Engineers are often said to be lacking in this respect. The cooperative course tends still further to emphasize this deficiency.

This is a mere assertion. Cooperative students participate as fully in college life outside of the classroom as do other engineering students. Furthermore, contact with men outside of the college assists materially in developing the student's social poise.

Under the close supervision of the cooperative system the student is likely to lose a sense of reliance upon his own resources and to expect as a matter of course that institution and employer will provide him with a suitable position upon graduation. In a word, there is danger that the cooperative system may exercise too much paternal control.

If this danger exists it should be guarded against. Placing the student in industry should not, however, have this effect. In fact, one of the distinct advantages of the cooperative plan is that it takes the student out of the regime of strict supervision by the faculty, and places him much more largely on his own resources in industry, where he is likely to see clearly that success depends upon his own initiative.

Disadvantages to the College and the Faculty

Depressions in industry affect student employment and may seriously interfere with the success of the plan.	The cooperative plan has weathered such depressions.
Employing concerns dominate the situation. There is seldom a choice of positions and the college is not able to select those providing proper experience.	It is entirely possible for the college to meet such difficulties. Industrial experience may be made subordinate to educational aims if properly organized and administered.
The administration of cooperative courses is more complicated and difficult than that of all-resident courses. A special corps of coordinators should be employed, thus entailing additional expense.	If the plan has merit, its adoption should not hinge upon matters of administrative difficulty. Any additional expense of the staff of coordinators is more than offset by increased revenue and the greater number of students accommodated.
If the institution has other departments operating on the all-resident basis, it is difficult to coordinate the instruction of the two groups of students. This is especially difficult when engineering students are enrolled in the same sections with students of other courses, as they often are in mathematics, English, chemistry and other subjects.	In such institutions the instruction of engineering students may be given entirely within the engineering department under a completely separate faculty. Or, if this is not practicable, alternation between college and industry may be arranged on a term or semester basis and all conflict with the schedules of all-resident students avoided.
It is very difficult, if not indeed impossible, to arrange for vacations of the teachers other than very short periods arranged on a "catch-as-catch-can" basis. This is extremely undesirable from every standpoint, and is testified to by teachers of cooperative courses as one of the serious objections to the plan.	This is another argument which does not apply to the plan per se, but only to the way it is conducted in certain of the institutions. The situation can be remedied by proper planning and the teachers given all the vacations really needed.

Disadvantages to Industry

The cooperative student is a liability during his periods of industrial experience and actually costs the industry money.	Employers are glad to procure cooperative students. Even if the student does not produce in proportion to his wages, the employer gains through obtaining graduates better adapted to his organization.
If all or a considerable number of colleges adopted the cooperative plan, industries could not absorb the students without serious interference with their operation.	Approximately 17,000,000 persons are employed in American industries, exclusive of agriculture. Compared with this figure the number of cooperative engineering students is insignificant.
Other employees, particularly foremen and superintendents, object to the presence of cooperative students and to the necessity of supervising them and of "breaking in" new lots of students at regular intervals. This upsets shop routine and decreases efficiency.	This may be true when cooperation is first undertaken, but it has been learned by experience that other employees soon adjust to the conditions and thereafter find no objection to the plan.
In some lines of engineering work continuity of attention on the part of the man handling the work is absolutely essential. In such work it would not be possible to have two students alternate on the job. This excludes the cooperative plan from positions in which really valuable experience could be required.	This applies only to certain types of work in certain engineering fields and is a condition of such limited application as not to be a serious detriment to the cooperative system as a whole or to its application in any of the major engineering fields. The number and variety of positions available to cooperative students, when all of the positions to which this objection applies have been subtracted, is amply sufficient to supply all of the needs of the cooperative system both as to kinds of work and value of experience afforded.

C. Testimony of Employers

Sources of Testimony.—A number of representatives of firms employing cooperative engineering students were named by several of the college administrators as qualified to express opinions on the merits of cooperative engineering education. Letters were sent to 44 of these firms; 29 replies were received, a few being incomplete. Their experience is based on the following periods of years and upon the number of engineering students indicated:

Length of Experience with Cooperative Students		Number of Cooperative Students Employed at Present	
Years	Firms	Students	Firms
1	7	1 to 5	10
2	4	6 " 10	6
3 to 5	4	11 " 20	6
6 " 9	5	21 " 30	3
10 " 14	6	31 " 40	3

Character and Purpose of Industrial Work.—Half of the firms which replied reported that work is not assigned to a student primarily with the idea of assisting in his engineering education; only one replied that it is, adding that the work is the same as that given to graduates who are being trained for the company's work. Six firms stated that the assignments are not primarily to aid the education of the student; but some of these firms stated that they try to give him varied experience; others, that they do not include common labor; etc. One concern gave as a primary object its desire to assist students in a financial way. Twenty of the firms stated in substance that the cooperative student is a profitable employee, two that he is not; one reported that it could make him profitable but that the student would then be the loser.

Almost all of the firms consider it essential, for the period of alternation employed, that the students be paired to maintain continuous service at the plants. To quote one opinion: "Our students are paired, and the time in each department is so planned that we are never short of a man. This we

believe is quite essential, and the foreman does not have to break up a machine crew to take the place of an absent student." For longer periods of alternation, fewer concerns deem pairing essential.

Questioned on the real value of the work given to cooperative students in promoting college engineering education of the highest type, representatives of thirteen firms said that the work offered in their plants has real value, one that it has not, and the others gave various opinions. On the other hand, ten replied that the work offered in their plants simply makes it easier for the graduate to fit into industry; seven others agreed to this, adding that it does more; one asked if this is not what engineering education is for.

Employers Favor the Plan.—To test the sentiment for and against the cooperative system of education, the three following direct questions were put to the representatives of industrial firms with results as summarized under each:

a. "Would you like to see more engineering colleges adopt the cooperative system?"

Nineteen answer *Yes*, one *No*, two are not sure, one doesn't care, and three do not answer. One large firm states that since only one-quarter of the students remain with it, more of them mean greater economic waste for it.

b. "Would you like to see all colleges adopt the system?"

Eight answer *Yes*, eleven *No*, one is indifferent and nine make no reply or are indefinite.

c. "Would you be just as well satisfied if the cooperative movement died out? That is, are you satisfied with the type of engineering graduates from colleges not using the cooperative system?"

Twenty-one answer *No* with varying degrees of emphasis, three are uncertain, two express indifference, and one says *Yes*.

It must be remembered that the replies summarized above were given, in general, by the individuals charged with the handling of cooperative students while in industrial employ and that these individuals as a whole might naturally be ex-

pected to view the cooperative system favorably. It does not follow that the same results would have been obtained by canvassing other officers of the employing firms. Even with this reservation, however, it must be concluded, in general, that firms employing cooperative students endorse the plan as having educational merit. The fact that they continue cooperation with the colleges after a fair trial of the plan substantiates this conclusion.

Quotations of Opinions.—Some interesting opinions on these questions are given below:

"I think some form of the cooperative system could be employed to advantage generally; provided, the length of the engineering courses could be increased accordingly. In other words, the time spent in industries should not be allowed to count as time spent in the laboratory or classroom. I do not think that the cooperative system without this additional time would be applicable to schools for advanced engineering. Possibly the cooperative system would keep some 'misfits' out of engineering."

"As a personal opinion, I believe that either an engineering college should be based on the cooperative plan wholly, or it should not undertake it at all. The cooperative plan should reach a class of students that could not afford a regular four or five year college education. I believe that industry can obtain men from both sources to advantage."

"Personally I think an uninterrupted four year college training is preferable to the cooperative plan. I consider that the latter plan affords an opportunity for college training to a class of young men who would not be able to devote four years to undergraduate work because of the heavy expense. I am inclined to think that the industrialist would withdraw his cooperation if too many colleges should enter the cooperative field."

"We are not fully satisfied with the general run of engineering colleges not using the cooperative system, or to put it another way, we find that in almost every case, natural ability being equal, the young man who has had the opportunity of a cooperative course is absorbable sooner and at a higher rate than the man who has not had the same training but has yet to have adjusted his attitude toward work and industry, and the relation of his education to practical work. This adjustment is the hardest job industry has to do,—to adjust the state of mind of the college man. When this can be satisfactorily accomplished, the rest is easy."

"Graduates after a year's experience old style are not equal to cooperative graduates. I believe the most competent man is the correspondence school man who completes his course, next to him is the cooperative student. If the man lacks the determination for these more difficult methods, I suppose he should receive his education in ease and luxury."

"Engineering students from non-cooperative colleges are just

as satisfactory. The principal benefit of the cooperative system to our organization is the fact that we can have students whenever we want them. We can also pick out the most likely students, thereby insuring a better class of helpers than we could secure anywhere else. The best ones are then retained after graduation if they desire to remain with us."

"A student who is willing to work to obtain his education will appreciate both his education and his job. Am heartily in favor of the cooperative plan."

"Undoubtedly, for certain types of men, this (cooperative) is the best kind of training, although we believe that this type of training is of more value to the men who go into practical work than into employment where theoretical work is the first consideration."

"I must say that some of our best men have come from the non-cooperative type of college."

"The movement could die out, for the good engineer is not dependent on the cooperative system. The good engineer should have practical experience along with theory and ability, but cooperative work is only one method of getting practice."

"This system could be adopted in more colleges and be of benefit providing that the men were sent to work in plants that would be able to use the men when they graduated. At present we are deriving no real benefit from employing the cooperative student but we are helping to supply the demand from other concerns. We know that this is so because the men when they graduate always seek employment elsewhere."

"I am satisfied that both are needed and that both have a field and obligation to society and industry."

"Unless the school, the industry and the student have some general, definite plan in mind, I do not think the maximum benefits will be obtained in cooperative courses. There should be no semblance of the indentured apprentice scheme, or promise to remain, because I do not think that would be fair to any of the parties concerned. However, unless all the parties concerned are training to some rather definite end, the maximum benefits will not result."

"One of our divisions tried to get all Cincinnati students this year. I am not quite sure of the figures, but I think they are as follows: Of forty-eight graduates, forty remained with the industry for which they were working. The other eight, for one reason or another, wanted to change to some other industry. Our division could get none of the eight. This is not entirely because they fit into industry so smoothly, but because they are very much higher grade engineers, and the demand is going to be many times the supply for quite a number of years to come."

D. Summary and Conclusion

The following paragraphs summarize briefly the inferences and conclusions which seem warranted by the foregoing statements of fact and opinion.

Educational Merits.—As a means of imparting the fundamental principles of science and engineering, the cooperative plan has not been shown to be either superior or inferior to the ordinary all-resident plan. If any inference is warranted, it appears to be that the two systems, *when conducted equally well,* produce equally meritorious results, though not of identical character. On the one hand there is no proof that the effort to coordinate industrial experience with instruction received in college results in greater learning efficiency or a better grasp of fundamental principles. On the other hand, proof is equally lacking that the discontinuity of instruction associated with the cooperative system results in any discernible decrease in educational efficiency.

Until more complete and conclusive evidence is available than that afforded by the facts thus far compiled, herein or elsewhere, or by the sweeping statements of opinion made both by the advocates and the opponents of the plan, judgment upon the scholastic merits of the cooperative system should be suspended.

Character Development.—Without attempting fully to discuss the cooperative plan from the standpoint of character development, the indications are that it should be credited with tending to develop, through actual trial, the student's stamina, resourcefulness, and sense of responsibility at an early age. In a word, the cooperative system provides a steadying influence which tends to mature the student. Some may feel that this is not wholly desirable. The college student is likely to be something of an idealist and to have a rather well developed sense of altruism. This attitude toward life, if properly fostered in college, is likely to carry over into years of maturity and leave a wholesome residuum to act as a balance to the sophistication of later life. The cooperative plan which advances the time of entry into the competitive atmosphere of industrial experience, may hasten the process of converting the idealist into the realist. This, in the last analysis, may not be an end wholly to be desired.

Orientation to Industry.—It can hardly be denied that the

cooperative plan provides a means of acquainting the student with the importance of the human element in practical affairs. Periods of industrial experience should give the student an insight into the reactions and point of view of the working man and thus equip him better to deal with the labor problems which he is likely to encounter in later years. Further, the cooperative plan seems unquestionably to offer the means of valid vocational guidance; actual trial being probably the one sure way of determining aptitude and liking for particular lines of work. The conclusion also seems warranted that the assimilability of the student to industrial organizations is increased, in fact this aspect of cooperative training is pointed out as one of its greatest merits by the employers of students and graduates.

Preparation for Operating Side of Industry.—The attributes of the cooperative plan in developing particular personal traits and points of view, together with the orientation to industrial organization which it affords, would seem to indicate that it is particularly advantageous as means of developing personnel for the administrative and operating side of industry. This, indeed, seems to be the peculiar merit of the system which is indicated most clearly. And it is by no means an unimportant one. The results of other studies in the general investigation of engineering education * show that a large (and probably increasing) proportion of engineering graduates are entering corporate employ and sooner or later occupying positions concerned chiefly with operating duties. American industry seems to be turning more and more to the engineering colleges for recruits to man the operating side of its organizations. If, as seems likely, the cooperative plan offers even a partial solution to the problem of training men for these positions, it undoubtedly possesses merits of very great importance.

Economic Aspects.—The economic aspects of the cooperative plan deserve careful consideration. It is clear that more students can be accommodated with given physical facilities. Just how large an increase is permitted depends upon several

* See particularly Bulletins Number 3 and 8 of this series.

factors, including, the period of the curriculum at which cooperative training begins and ends, the length of the academic year, distribution of enrollment by classes, and the proportion of time devoted to college and to industrial work. On the average, it is probable that from 33 to 50 per cent more students can be accommodated under the cooperative plan when used throughout the entire course. This results in a reduction of capital expenditure per student and is a matter of great importance. The costs of higher education are high and probably are increasing. Engineering education is one of the most expensive forms of higher education.* Any plan which offers a means of reducing capital expenditures without decreasing the effectiveness of the educational processes warrants the most serious thought of all concerned.

From the standpoint of the student desirous of going to college but without sufficient funds to pay all of his expenses, the cooperative plan is undoubtedly attractive since it guarantees him an opportunity to earn a substantial part of his expenses. Offsetting this advantage there is the added time required to complete the undergraduate course. If five years from date of admission to college be considered and allowance made for the earnings of the all-resident student during vacations and during the first year after graduation, there is little difference in the total earnings of all-resident and cooperative students.

Other claims of the financial advantage of the cooperative plan are not wholly substantiated. In particular it seems probable that the lower cost of operation, and especially of the lower cost of instruction which obtains in some instances, are due to the intensive manner in which cooperative courses are commonly operated and to added burdens on the teaching staff, rather than to any intrinsic features of the plan.

It is obvious, of course, that if the same tuition be charged per year in five-year cooperative courses as in four-year all-resident courses, additional revenue is obtainable from this source. This has been mentioned as one of the financial advantages of the cooperative plan.

* See Bulletin Number 6 of this series.

Causes of Growth of the Cooperative Plan.—It may probably be seriously questioned whether much of the growth of the cooperative plan has not been due to its attractiveness in reducing the investment in facilities and in providing for the self-supporting student rather than to its fundamental educational merit. To institutions considering the establishment of engineering courses or already providing such courses without adequate resources, the cooperative plan seems to offer not only the means of reducing initial outlay but also of insuring a student body and of increasing the revenue from tuition fees. Neither of these motives ought to be criticized, provided always that the cooperative plan does not serve as a disguise for insufficient facilities, for an inadequate and overworked teaching staff, and for low educational standards generally. It is to be feared that this has been the case in some instances and that much of the real merit of the cooperative system, when pursued under the proper circumstances, may be lost sight of because of the manner in which it is sometimes conducted.

Relationship of the College to the Community.—One aspect of cooperative engineering training not mentioned specifically in any of the discussions of correspondents but which seems worthy of attention is what may be termed "the integration of the institution with the community." Since it offers a means of serving students who might otherwise not be able to attend college and also provides a direct relationship of undergraduate work with the activities of industrial concerns, the cooperative plan would seem to bring the institution into closely articulated relationship with both the homes and the commercial and industrial activity of its community. It may be that this apparently direct service to the municipality, whether explicitly recognized or not, has been a factor in the adoption of the cooperative plan by a number of municipally supported institutions and also by those institutions which, while not directly subsidized by the municipality, nevertheless have a close relationship with it. This phase of the cooperative plan undoubtedly has publicity values

which urban institutions might, and in some instances do, capitalize.

The Non-Graduating Student.—Another matter to which attention may be directed is the value of cooperative courses to the student who is unable to complete his course. As pointed out in Bulletin No. 2 of this series, approximately five of every eight students admitted to engineering courses fail to graduate. The problem of providing as much as possible of value to these students is a very serious one, applying as it does to a majority of those admitted. It would seem especially appropriate for publicly supported institutions to consider it carefully. Some advocates of the cooperative plan point out that cooperative courses serve as a natural selective process in which the student continues to the point which his natural ability, purposefulness, and aptitude for industrial pursuits qualify him to achieve; and that he then steps off into regular employment with a background of both academic and industrial training of an extent proportional to his ability and to the type of position that he is qualified to fill. This is a contention which, obviously, it would be very difficult fully to substantiate; it would seem to be largely an ideal rather than completely an actuality. Nevertheless there seems to be an element of justification for it in the conception and principles of the cooperative plan as well as some basis for the belief that the system does tend, at least, to produce the results claimed. If so, it is a feature which should be duly weighed in any appraisal of the cooperative system.

Practical vs. Philosophical Values.—The summarized statements of the opinions of those canvassed do not touch upon the important question of whether cooperative training serves as well on the more philosophic side of the student's education as it does on the side of the practical and the concrete. A scheme of life which keeps the student at assigned work throughout practically the full academic calendar year, alternating between study and practice at fairly short intervals, and which in some cases adds to the intensiveness of the

scholastic schedule, can hardly be expected to promote reflective thinking. Contacts with the practical concrete problems and with the hard-headed supervisory personnel of industry are fairly certain to develop the student's "horse sense" and counteract his tendency to seek involved ways of doing simple things. This result is excellent as far as it goes, but there is a likelihood that constant emphasis on practical knowledge and empirical judgment may lessen the student's respect for more abstract knowledge and react unfavorably on the development of his higher analytical powers and his capacity for generalized thinking. How largely these suppositions are true, what relative emphasis may best be given to the two types of training, both good, and what preparation leads to the highest ultimate development, are likely to remain speculative questions for some time. Forty years of experience, rather than twenty, may lead to a more decisive verdict.

Conclusion.—Cooperative engineering training has passed through an initial experimental period and is now firmly established in the general field of engineering education in the United States. It has been adopted and is working successfully in several of the strong institutions of the country. This fact alone, if there were none other, is proof that the plan has merit and deserves a recognized place in engineering education. On the other hand, few except the most ardent advocates of the system will probably hold that it should be adopted universally. It is a plain fact that all-resident curricula in engineering, though they are certainly open to improvement, are, in general, successful in accomplishing their purposes. Neither all students nor all institutions, nor all types of engineering services, are best served by a single, uniform, standardized type of program. The field of engineering is immensely broad. Engineering graduates function throughout its entire range from the executive management of huge industrial enterprises and from professional services of the most expert character on the one hand to minor types of technical and operating services on the other. In this

diversified field cooperative training seems unmistakably to have its proper place. The indications are that its particular function and peculiar merit is in training men for the operation of industrial enterprises. That many young men pursuing cooperative courses will become highly competent designers or researchers, and that many all-resident students will attain to positions of importance in the operating side of industry is undeniable, but it is probable that the cooperative program tends, on the average, more directly to prepare students to adjust themselves promptly to the requirements of administration and operation.

PART IV. BIBLIOGRAPHY

Although the cooperative plan has been in operation in this country for twenty years, there have been very few careful and specific discussions of it in print. The most comprehensive bibliography on the subject is given by Clyde W. Park in his "The Cooperative System of Education." The present bibliography, which applies to articles which have been published in the United States, was compiled after an examination of all of the 104 items listed by Professor Park and a number of others found by a search of the files of the publications of the various engineering societies, of the Proceedings of the Society for the Promotion of Engineering Education, and of the United States Bureau of Education. A search has also been conducted through the Engineering Index and the Index to Periodical Literature. It is quite possible that certain articles have escaped detection, though it is believed that the important ones have been included.

In the present instance it was thought advisable to depart from the usual custom of listing all titles relating to a given subject, and instead to give only those of such importance as really to warrant the reader's attention. All discussions of industrial education in general, articles referring to cooperative education in the secondary schools, those which are merely brief comments, those whose subject-matter has been gathered up and embodied in later articles, and others which seemed unimportant have been discarded. The shortness of the list which remains attests the fact that the literature on cooperative courses is not nearly so extensive as the importance of the subject would seem to warrant.

For the reader's convenience in selecting articles for reading or study, the bibliography herein given, in addition to listing the titles and the sources from which publications may be obtained, presents a brief summary of the more important features of each article. It is hoped that this descriptive feature of the compilation will add to its usefulness. Since

the usual arguments in favor of the cooperative plan are stated, at least in part, in almost every discussion of the subject, and since these arguments are fully and admirably presented in Professor Park's booklet, they are in general omitted in the synopses of the articles listed below.

Anonymous. "COOPERATIVE RAILWAY ENGINEERING COURSES: CENTRAL OF GEORGIA RAILWAY AND GEORGIA SCHOOL OF TECHNOLOGY WORKING OUT AMBITIOUS PROGRAM." *Railway Age:* Vol. 77, No. 21, Nov. 22, 1924, pp. 921–924. (Illustrated.)

The Georgia School of Technology offers both all-resident and cooperative courses. This article presents several of the usual arguments in favor of cooperative courses. Physical requirements for admission to the cooperative courses are stringent, owing to examinations conducted by the Railway. Students work in the Central of Georgia Railway shops and alternate with resident instruction at four-week intervals. They cover as much ground in theory while in college as the regular students. It is said that they cover it more intelligently. The Railway endorses the cooperative plan. The article was written when the plan was in its second year.

Alexander, M. W., and Jackson, D. C. "REQUIREMENTS OF THE ENGINEERING INDUSTRIES AND THE EDUCATION OF ENGINEERS." *Mechanical Engineering:* Vol. 43, No. 6, June, 1921, pp. 391–395.

A valuable discussion of the educational philosophy underlying the cooperative plan of engineering education, particularly from the standpoint of preparation for industrial experience. Reasons are given for the adoption of a cooperative curriculum in electrical engineering by the Massachusetts Institute of Technology under an agreement with the General Electric Company. The following digest of the article appears as an introduction in the publication above mentioned.

"A combination of empiricism and training in rational science is needed in engineering education because it is needed in the engineering industries, and this consideration has led

to various plans for placing engineering students within the influence of industrial operation, the most common being for engineering college graduates to enter industrial establishments as 'cadets,' 'engineering apprentices' or 'student engineers.'

"The first comprehensive, organized plan for bridging the gap between academic and practical training of the young engineer was made operative in the United States in 1906 when Herman Schneider, Dean of the Engineering Department at the University of Cincinnati, organized a cooperative engineering course in connection with the metal-manufacturing plants of that city. Schneider's ideas lie at the base of the cooperative plan which the authors succeeded in organizing a few years ago in connection with the Massachusetts Institute of Technology and the Lynn Works of the General Electric Company, and which is described at length in the present paper.

"This cooperative engineering course covers a total of five years, the first two being identical with the freshman and sophomore years at the Institute and the last three being divided between instruction in theory at the Institute and instruction in practice at the Lynn Works. In these last three years the total time occupied in studies at the Institute and practice at the Works is eleven months per year. The first term of the cooperative period, extending through thirteen weeks, is spent at the Works by all of the students during the summer period immediately following the sophomore year at the Institute. The succeeding terms of similar duration are spent alternately by each half of the student group at the Institute and at the Works, while the final term is spent by all the students at the Institute for additional advanced instruction and the preparation of a master's thesis prior to the college commencement.

"During their assignments at the Lynn Works, students are subject to the usual rules and regulations applying to employees of the General Electric Company, and on a full week's work schedule receive compensation at the rate of $21 per week at the beginning of the course and $24 at the end.

"The joint supervisory committee of the two institutions believe that this experiment in cooperative engineering training will exert a most beneficial influence upon the relationship of the engineering college to industry and upon the activities of each. They are clear in their own minds, however, that the cooperative training in engineering must not and cannot replace the regular engineering courses at colleges which in the nature of things must cater to the majority of young men seeking a thorough training in the engineering sciences, and many of whom do not enter the manufacturing industries. The cooperative training, however, is destined to become a vital integral part of a comprehensive system of engineering education, to the detriment of none of the other parts, but to the mutual benefit of all, and is particularly important to the manufacturing industries of the nation."

Alexander, M. W. Discussion of Timbie's "COOPERATIVE COURSE IN ELECTRICAL ENGINEERING OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY." *Journal of the American Institute of Electrical Engineers:* Vol. 44, No. 10, Oct., 1925, pp. 1128.

Two features of the cooperative course described by Professor Timbie might with profit be adopted by any educational institution:

First, since in the cooperative course, the college year is increased from thirty-six to forty-eight weeks, the entire course might be completed in three years. The year saved, if put to useful employment, would enable the student to acquire actual experience and hence integrate himself in industry. Or, if the year saved should be devoted to further study, his education might be deepened in the basic sciences of engineering and broadened in the general subjects.

Second, cooperative courses fix the student's mind on application of principles to practice, thus giving him a true perspective for his theoretical and scientific work. This is a lesson which those who do not adopt the cooperative plan might learn.

Cincinnati, University of. Articles on the cooperative plan as practiced at this institution; arguments for the plan, its purpose, methods, results, etc., have been numerous within the past fifteen years, and have been published in various periodicals devoted to engineering as well as in the popular periodicals. The authors in the main are connected with the university, notably Dean Herman Schneider and Professor Clyde W. Park. The substance of almost all of these articles and studies is presented by Professor Park in the one comprehensive study listed under his name in this bibliography. It comprehends, supplements, as well as supersedes, all that was written on the subject prior to its publication.

Faig, John T. "The Effect of Cooperative Courses Upon Instructors." *Engineering Education:* Vol. 3, No. 7, March, 1913, pp. 493–502.

Based on the experiences of instructors at the University of Cincinnati only. States that the types of cooperating industries affect academic schedules and the subject-matter of various courses; that practicing engineers, executives, foremen, etc., have a beneficial influence upon instructors by their suggestions and their reports of students' progress; that cooperative students influence instructors by their requests for information of a practical nature, by their interest in certain subjects, and by their reflection of the attitude of workmen in the industries.

Hallock, J. W. W. "The Cooperative Plan of Engineering Education." *Engineering Education:* Vol. 8, No. 1, Sept., 1917, pp. 12–24.

Gives features of the cooperative plan and its workings at the University of Pittsburgh. None other than cooperative courses are offered in engineering. Cooperation begins with the sophomore year. Periods of alternation are three months. An outline is given of the duties of the Director of Cooperation; blanks for foreman's report and names of cooperating firms are also given. The outstanding advantage claimed for the plan is that it forestalls the apprentice period. Stories of

typical student cases are given. Several objections to the plan are stated, but in general it is given hearty endorsement. Reports from alumni graduated under the cooperative plan indicate a highly favorable attitude toward it.

Kolbe, Parke R. "THE PART TIME PRINCIPLE IN EDUCATION." *Educational Review:* Vol. 50, Nov., 1915, pp. 348–359.

A statement of the arguments in favor of part-time education in the professions, with incidental application to engineering. A clear and cogent presentation of underlying principles.

Matheson, K. G. "COOPERATIVE ENGINEERING EDUCATION." *Engineers and Engineering:* Vol. 39, No. 11, Nov., 1922, pp. 384–386.

Many institutions have established non-commercial shops in order to coordinate theory and practice. Objections to this policy lie in the excessive expense of keeping equipment up to date and lack of time for adequate shop practice. Worcester Polytechnic maintains a commercial shop; Antioch College proposes to establish such shops. The University of Cincinnati plan is a feasible solution of the problem. A description of the plan is given. The cooperative plan was established at the Georgia School of Technology in 1912, and was successful, union laborers in the industries making no objection. The University of Akron, Georgia School of Technology, Lafayette College, New York University, University College (Boston), Massachusetts Institute of Technology and Harvard University practice the cooperative plan, and Drexel Institute proposes to establish it. Arguments in favor of the plan, which are presented, are said to be overwhelming.

Park, Clyde W. "THE COOPERATIVE SYSTEM OF EDUCATION." *University of Cincinnati Studies,* Series II, Volume XI, Part I, 1925. (A reprint of bulletin No. 37, Series of 1916, U. S. Bureau of Education, with additions.) 102 pp. Illustrated. Bibliography.

This bulletin presents the entire history of the cooperative

system of engineering education at the University of Cincinnati, the first institution to practice it, together with its purposes, methods, development, results; it includes tables of curricula in various courses in detail, report blanks, work sheets, office records of students, specimen work reports, description of courses, statistics of enrollment, etc., etc. It is a complete and highly satisfactory statement based on the experience of an institution that has practiced the cooperative plan for almost twenty years and has found it satisfactory in its results.

This account of the cooperative system is by far the most complete and elaborate yet attempted, and is indispensable to any investigator of the subject. It is too long to summarize even briefly and, indeed, is so full of valuable matter that it should be read completely and with care. While it presents only one side of the subject (nothing is said to indicate that any arguments may be advanced against cooperative education), it strikes the reader as an honest statement. Its survey is limited to the University of Cincinnati; there is no attempt at a comparative study.

Roe, Joseph W. "THE COOPERATIVE PLAN OF ENGINEERING EDUCATION." *Management Engineering:* May, 1922, pp. 269–274.

This seems to be the only truly comparative study of the cooperative plan that has appeared in print. It begins by discussing five plans of engineering education (a valuable synopsis), the fifth being the cooperative plan, traces the origin and growth of the plan at the University of Cincinnati, and then outlines the working of the same plan, or modifications of it, at the University of Akron, Antioch College, Northeastern University, Georgia School of Technology, University of Cincinnati, Harvard University, Marquette University, New York University, Massachusetts Institute of Technology, and the University of Pittsburgh. Tables are given to show the growth in numbers in the cooperative courses and comparisons and made between these and the numbers in the regular

courses. Four diagrams show the length of the periods of alternation between the college and industrial periods at several institutions. The author states that the cooperative plan is not uniformly successful, the success being dependent upon the quality of coordination. He outlines the qualities desirable in a coordinator and outlines his duties. He states that the experience of employers is favorable to the cooperative plan.

Sackett, R. L. "DEVELOPMENTS IN COOPERATIVE ENGINEERING COURSES: A REVIEW OF THE VARIOUS ALTERNATE INDUSTRY AND CLASSROOM COURSES GIVEN IN DIFFERENT AMERICAN COLLEGES." *Engineering News-Record:* Vol. 90, No. 24, June 14, 1923, pp. 1050–1051.

Presents brief accounts of the cooperative plan as practiced at the University of Cincinnati, Massachusetts Institute of Technology, New York University, Harvard University, and Antioch College. States the obvious advantages of the plan as they are presented by all of its proponents. Also states the disadvantages at some length, and insists upon them: among others that the cooperative student (*a*) is largely deprived of participation in college activities; (*b*) has little time to cultivate college spirit; (*c*) is encouraged by the very nature of his training to take a materialistic attitude toward life—a tendency that education ought to counteract, not foster; and (*d*) maintains that the entire cooperative scheme places cultural education—that is, really professional education—in jeopardy, by making a complete sacrifice to industry. Pennsylvania State College meets the demand for practical training without sacrificing anything essential. "We are firm in our belief that it is not our province to give trade training, and that we are responsible for a broad cultural course, with a professional outlook; that we are responsible for thorough instruction in the fundamentals and for planting such standards of life in the minds of students that they will be able to serve society according to their capacities, to enjoy their work, and to use their leisure to advantage."

Smith, H. B. Discussion of Timbie's "COOPERATIVE COURSE IN ELECTRICAL ENGINEERING OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY." *Journal of the American Institute of Electrical Engineers:* Vol. 44, No. 10, Oct., 1925, pp. 1127.

The author asserts that the closer the contact between industry, engineering organizations and the colleges the better the product of the colleges. A discussion is presented of a modification of the Cincinnati plan practiced at the Worcester Polytechnic Institute. Students leave the Institute at the end of their junior year for a period of fifteen months devoted to organized industrial experience, returning at the end of that time to complete the work of the senior year. Fifty students have pursued this course, only one of whom failed to return to complete the college course and obtain the degree. Experience with the plan has been favorable from the standpoint of the Institute.

Timbie, W. H. "DISTINCTIVE FEATURES OF A COOPERATIVE COURSE IN ENGINEERING." *Engineering News-Record:* Vol. 85, No. 3, July 15, 1920, pp. 119.

An account of the cooperative course in electrical engineering offered jointly by the Massachusetts Institute of Technology and the General Electric Company. Covers much the same ground as Professor Timbie's later article (listed below) and the article by Alexander and Jackson (listed above). The General Electric Company cooperates in training students; the length of time spent by the student in each department of the company is regulated solely by the value of the experience to the student, not by the needs of the department. Careful provision is made for the continuity of theoretical and humanistic studies, including liberalizing reading and the study of English in various phases.

Timbie, W. H. "COOPERATIVE COURSE IN ELECTRICAL ENGINEERING OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY." *Journal of the American Institute of Electrical Engineers:* Vol. 44, No. 6, June, 1925, pp. 613–617.

The following synopsis appears as an introduction in the publication listed above.

"There is no standard cooperative plan of education. A cooperative course takes on the ideals, purposes and standards of the school and companies cooperating.

"The purpose of the Massachusetts Institute of Technology is to give young men well grounded knowledge and specialized information combined with a broad education and the power to apply theories of science to the practical requirements of industry. The cooperative course in electrical engineering at M. I. T. naturally has the same ideals and purposes.

"The course is five years in length and offers a degree of Master of Science to those who complete it. Only the last three years are cooperative, the first two years being practically identical with the regular electrical engineering course.

"The regular school year consists of two terms and a summer vacation. The cooperative year includes the summer in its schedule and has three terms to the year, two of them being coterminous with the regular Institute terms. During the last three years the cooperative students spend every other term (practically five months) at the plants of the cooperating companies, any one student always going to the same company. The practical experience thus occupies eighteen months of carefully selected and supervised work in the industries. The student has the choice of a manufacturing company or a public utility company, providing he meets the Institute standard in scholarship and the company's standard in personality and natural inclination. He is paid at an hourly rate depending upon his length of service with the company, each student earning about $1,500 during the three years. The last year is spent upon post-graduate study and research both at the Institute and with the company. The student is under no obligation to stay with the company after gradua-

tion nor is the company obliged to hire him. To date, 47 per cent of the men have remained with the cooperating company.

"While at the plants of the cooperating company, the student continues to carry two of his Institute studies, two evening classes per week being conducted by members of the instructing staff at the Institute.

"Main features. 1. The course aims to train a carefully chosen group for engineering service of the particularly high order, in manufacturing and public service companies.

2. The theoretical part of the regular electrical engineering course has not been cut in order to make room for the engineering practice. On the contrary a year of postgraduate work has been added, for which a degree of Master of Science is granted.

3. The engineering practice for a student consists of a course of experience, carefully planned and supervised. It is not merely a series of jobs.

4. The student spends all of his cooperative periods in the employ of one company getting a unified conception of organization and company policy. He learns the meaning of team work and loyalty.

5. Fluctuating business conditions do not interfere with his engineering practice.

6. The practical experience reacts on his theoretical work, explaining it and making it real to him.

7. His theoretical studies are not interrupted during his practice periods. He gets the habit of working days and studying nights, a habit which experience proves is hard to break in later years.

FOUR, FIVE AND SIX YEAR CHEMICAL ENGINEERING CURRICULA *

BY JAMES R. WITHROW,

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As a training there can be no question five years are better than four and six should be better than five. If there were no collateral factors there could be no further discussion of this question. To be somewhat thorough we would of course investigate the possibility of entertaining opposing views. As a matter of fact we were all brought up face to face with several factors which make other points of view not only tenable but useful. If the school could produce engineers, even these collateral factors would scarcely ever become dominant. As the engineer is developed only on the job, the effort of the schools is consciously aimed at a thorough foundation and introduction. No one expects the graduate of a six or eight year law or medical school to be a lawyer or a doctor. They must practice. Some very useful effort has been made in chemical engineering education quite in advance of most forms of technical training, to inject some practice directly into the curriculum.

This set-up of the educational problem makes clear that the question of length of course is complex. It may serve some useful purpose therefore to recall in a sketchy manner some phases of a few of the collateral factors which serve to influence the tentative solution of the four, five or six year curriculum question. As far as any given institution is concerned the solution of any such question is usually a tentative one merely. Hence the value of free discussion.

* Read by invitation of The Committee on Chemical Engineering Education of the American Institute of Chemical Engineers at the Conference on Chemical Engineering Education under the auspices of the American Institute of Chemical Engineers, March 26, 1926, Columbia University, New York City.

Four years is the ordinary standard length of University and technical education in America. Longer formal study or training however is gradually increasing in demand. This demand comes from students, teachers and industry. Students without doubt will follow custom or opportunity. Teachers will follow and recommend the need, as their experience sees it, and as discussion develops the matter. Teachers of technical subjects such as chemical engineering and industrial chemistry will at least be independent and impartial in any decision regarding length of course. If anything, their personal feelings will incline toward longer training since they meet only advanced students, and on the average the longer course will tend to have fewer students in the advanced years, reducing teaching load.

Extended Curricula Tendencies

Extension of curricula has long been in progress. Many of us can remember the day in our university or technical schools when special courses were operated. There were the Short Courses, so called, especially adapted to mechanics and other workers who had late in life discovered the need of educational breadth along with special technology. There were also the special courses, one, two or three years in length, generally the latter, which supplied the demand from a similar group who often had the requisite entrance requirements lacking in most of those who entered the short courses. The students in the special courses were usually men of snap and vigor, who also had entered college after the normal time, though not so late as the short course students, but who did not care for a degree, and who usually omitted general or cultural subjects.

Neither of these arrangements led to a degree, and both of them included students fresh from the high school, as well as the groups mentioned. Both of them also produced many men who are now leaders in the engineering world.

The regular high, or preparatory school graduate who entered the University or technical school usually pursued the

longer course leading to a degree at the end of the fourth year. He was classed as a regular student and looked upon as such. He comprised all variations of ability and possessed varying appreciation of opportunity. He quite frequently was merely continuing his education, with little definite appreciation of the meaning of it all, since he usually had not supported himself.

The short and special courses have gradually been extinguished for various reasons. No educational procedure is necessarily final, and the extinction of short or special courses does not mean that they should not be revived should adequate reason present itself. However, it is the general feeling at present that engineering students should, if possible, be given the standard four-year curriculum at least. Entrance to such work is discouraged without adequate entrance requirements slightly in advance of those for general university work. This advance characteristic usually means particular foundation in certain phases of mathematics.

Graduate Work

It seems likely that four years will always be the standard length of university work leading to a first degree in spite of a few exceptions. A fifth year as graduate work is readily available, normally bringing a Master's degree. Two years more or a total of seven years brings the student to the Doctorate (Ph. D.). The demand for this work is increasing and the route is well developed and standardized in this country. It is the opinion of the speaker that graduate work will be much improved in tone and value as engineering graduates enter it in increasing numbers.

Without wishing to detract in the least from the merit of the students of other colleges, the speaker has for long emphasized to the Dean of the Graduate School of the Ohio State University that the graduates of chemical engineering courses in this country constitute the finest graduate school timber available.

Growth of the Professional School

While this graduate route to five and more years of university training was slowly developing, other factors were at work in higher education influencing length of course. The outstanding case is that of medicine. Other professions such as law might also be mentioned. There has come about in higher education therefore a strong professional urge to lengthening the curricula. The movement has had various energizing factors. Undoubtedly the principle one was the need for a deeper and broader cultural and scientific foundation upon which to build professional or technical training made necessary by the widening spread of education in general and the rapid march of scientific and industrial development. Those professions at least which come into daily man to man contact with increasing numbers of broadly educated clients found lengthened curricula the necessary means of promoting adequate professional status.

If not always in law at least in medicine the rapid expansion of scientific knowledge made deeper foundations in science the sine qua non of a real advance of the subject itself.

Other urges there were a plenty. Some lawyers appear to have felt that there were enough lawyers, and a little curtailment of supply would do no harm. The country does not appear to have objected perhaps because we do not appear to have had an engineer for president since George Washington, as is erroneously stated from time to time.

This general movement for curriculum extension, whatever its basis, gave us the professional school—work largely built upon two or more years in Arts or cultural studies or even upon an Arts degree.

Influence of Curtailment Factor

The curtailment of supply of young members of the profession partly due to enforced or required lengthening of curriculum will early become a matter of public concern, at least in the case of Medicine. The value of the longer curri-

culum here is probably unquestioned but the growth of communities throughout the country, with increasing population, entirely destitute of medical service is arousing alarm and is a matter of discussion in our universities. The fact that medical service can come from the big cities in high powered cars at infrequent intervals and leave high powered bills for little or no examination, let alone service, does not promote very rapidly the common welfare. To the fact that the rural citizen has for some time been increasingly acquiring such benefits of civilization as the privilege of dying without benefit of clergy, is now being added the privilege of dying without benefit of science. He may be saved an incompatibility over evolution but his survivors will be more interested in professional curricula.

This curtailment factor has also a bearing upon the length of engineering curricula and the welfare of industry.

Extended Curricula in Engineering

While engineers may not have worried so much about professional status as other groups, nevertheless engineering is a profession. Engineering education has therefore long raised the question of length of curricula from all angles which have effected other professional education.

Engineering teachers are always interested therefore in discussion of the length of the curriculum. Even if other professional groups were not active this would be true, for probably no other branch of teaching is so profoundly interested in discussion and criticism of teaching methods and arrangements. As far as I know, no other branch of higher learning has had a society devoted for many years to the questions of education. The Society for the Promotion of Engineering Education has long been a vigorous organization, furnishing an outlet for much of the thought and study constantly being given to engineering teaching methods by those engaged therein. This gives these engineering teachers an advantage over most other teachers.

Throughout the years, teachers of engineering, in common

with other educators, have asked themselves, (1st) whether too much is not being forced into the four-year curriculum, and (2d) would the student not be better prepared to meet the demand of industry if his course in the University were lengthened?

Numerous educational experiments and developments have been conducted to answer these questions and with a substantial degree of success. It is probable that almost every institution represented in this conference is administering some form of lengthened curriculum. I need not mention to this body the conspicuously successful cases of extended curricula in chemical engineering. It is to be ardently hoped that such experiments and such developments will not be discouraged, but will continue. It seems natural as the average length of life is prolonged, that more time be given in the preparatory part of it. It would not seem unreasonable, therefore, if in due time a great group of engineering students should subject themselves to the equivalent of six or seven years of University preparation.

The Four Year Curriculum a Fixture

The general economic prosperity coupled with the continued demand from the industries, and the natural ambition of citizens in a democracy for the future of their children has brought and will continue to bring an ever increasing number of students into higher institutions of learning. For this group four years will probably continue to be the limit of educational possibility for economic as well as traditional reasons.

Whether this prosperity expansion in student numbers had occurred or not, the Arts and other colleges of the country are wedded to a traditional four years for a Bachelor's degree. They are proud of the fact that they are the largest in numbers in their student body. They resent movements which tend to curtail these numbers. Their objection, to be sure, is not frankly to loss of numbers, but rather to the diversion of interest away from the Arts or cultural point of view.

They feel they are preparing citizens for life and that this must necessarily prepare them for business also. If they are preparing for a profession they feel the Arts foundation is also a good one upon which the profession should be built. The articulation in this regard with medicine is well-known. The articulation with engineering is not so successful, although it has met with results.

The Arts college advises for the fifth year a Master's degree and for additional work a Doctorate, requiring seven years in all. This educational situation must be kept clearly in mind as it has a profound effect upon the interest of the student. It furnishes an alternative route to approximately the same industrial chemical responsibility and opportunity. Those of industrial and particularly of engineering experience realize the shortcomings of mere chemical training. It is another thing, however, to warn our students and still worse our otherwise very competent professors of Chemistry. Where there is no vision the people perish. The speaker has been told by more than one professor of chemistry in his own university that "anything you can do in a beaker you can do in a tank." "Anyone trained in chemical theory can solve any problem in industry." Our wishing this were true, is little contribution to one whose experience brings nothing to the question. It is necessary to take the training of chemical engineers out of the hands of teachers of chemistry, though it must not be forgotten that to teachers of chemistry we owe the vision of a need for chemical engineering training and not to teachers of engineering.

The engineering teacher experienced in the professional or technical branches, because he has usually been a man of actual industrial experience, has tended to emphasize the fact that the university of technical school gives the student the opportunity of laying a broad foundation in elementary fundamental subjects and that his real education is largely secured in the "University of Hard-Knocks." We seem a little timid as teachers in emphasizing what we have discovered in our own experience: that 80 or 90 per cent of engineering

experience is *common sense* coupled with *accuracy* and *reliability*. It is the aim of engineering education to lay a foundation which will make possible the full development of these powers by the individual. If there is a criticism which we have had everlasting recurring, it is the failure of human beings in these three essentials. Engineers or technical graduates have not been free therefrom. This strikes at the very root of education, and is confined not at all to engineering students.

Thus we see that whether from the point of view of the engineer who by a residuum of the old apprentice order "learn in contact with responsibility," believes the school should confine itself strictly to fundamentals and put the man at the earliest date with industry, or from the point of view of the graduate school method of curriculum extention, there is a distinct stopping place at the end of the fourth year or at the normal place for the B.S. degree. At this point the student can smoothly proceed as a beginner into industry or proceed to some form of advanced or continuation training. Industry in some branches of engineering furnishes its own advanced or continuation training for the college graduate in its cadet systems well known to you. Thus we see the four year curriculum in some form is probably a fixture. There exists almost a necessity for a degree at the end of four years. This is obviously no reason for lack of interest in extension beyond the four year period. It also should not interfere with any particular system of extension.

Curriculum Extension

The feeling among deans of technical institutions in the Mid-West seems to be along the line of the possible arrangement of a fifth year added to engineering to be devoted rather exclusively to cultural and non-technical subjects. The difficulty lies in the decision as to the point of insertion, whether at the beginning or distributed throughout or at the end. The latter seems psychologically impractical, though the student could appreciate it at that point. In any event everyone is

awaiting the finding of Mr. Wickenden's investigation of the facts of engineering education.

The case of chemical engineering is more complicated than any of the other curricula in engineering. Its history is a factor which must be taken into account. Long before we had chemical engineering curricula, students were acquiring enough of chemistry in the universities and technical schools to meet to a certain extent many types of demand in the industries for chemical service.

The science of chemistry is so useful to mankind that we apply it in widely divergent fields. Chemical manufacturing and the application of chemistry to manufacture are but a portion of the usefulness of this science in its applications. One needs only mention agricultural chemistry, physiological and medical chemistry, and pharmaceutical chemistry, to realize that chemical engineering, important as it is, is but one of the demands for chemical intelligence in the world of affairs.

Chemical engineering, too, is important. Without doubt, it is increasingly destined to be the hand-maiden of all the other branches of engineering. Engineering will expand and develop as chemical engineering develops. Already the Mechanical Engineer realizes that his power design is a function of metals and refractories. Civil engineering is dependent upon concrete and water proofing; electrical engineering upon special insulation materials, metals and glass; mining engineering is closer still to the chemical engineer, as are ceramic and metallurgical engineering. The architectural engineer is increasingly turning from natural materials and taking up with chemical products for the strength and effects which are demanded of him. This vision of chemical engineering is clear enough to us, and our job is to make it so clear to education in general that chemical engineering may receive an increasing support over that which is given to it now at any institution.

Since rapidly expanding industry is compelled, and is glad to welcome men trained in chemistry by whatever method,

the chemical engineer has always a competitor for place. It will therefore be a serious question whether we can justify asking men to study chemical engineering through an extended number of years, as long as he can enter any arts college in the land, major in chemistry, taking a few fundamentals of engineering, such as mathematics, physics, mechanics, drawing, then pass on into a Master's degree or a Doctor's degree in any of the branches of chemistry and go out into the industries with the advanced prestige of a Doctor's degree. Industry is increasingly making place for such men with no introduction to application whatsoever. In industry they then must make their way and pick up the applications and many producers prefer to have their men do this.

Most of us doubt whether this situation is ideal even if it seems useful. We cannot deny that.

It is more attractive if one is to spend six years in college to take a Master's degree in five years, and a Ph.D. in two years more, by adding one year to the other time.

Obviously the men with the chemical engineering training have more jumping-off points, to be generally useful, than any other type of individual. Industry however will do with what it can get.

Under the competition with the graduate school arrangement, a six-year curriculum in chemical engineering could only be feasible either under extraordinary inducement in the shape of unusual features and publicity or at institutions situated in congested manufacturing regions where serious curtailment of student numbers could be survived or where such curtailment was desirable. It could be expected to function like a limited enrollment. In special cases, and in fact rather frequently, raising requirements increases enrollment.

It is doubtful whether engineering education can ever go on a strictly professional basis. It lacks certain of the apparent essentials to such a method of organization. For instance, it can scarcely expect to get uniform laws and examinations for permission to practice which could be used to

eliminate the product of the school not up to standard. In fact there is violent opposition particularly among chemical men to *any* form of state licensing of engineers. The engineers in such a state as Ohio are so divided on the subject that no law has even been agreed upon. Even American Engineering Council takes no stand in the matter and merely suggests a form of law for the guidance of those interested. Medicine has fought that battle through. Then, too, there is no united organization which dictates to school, press and legislature as in medicine. We will always be divided between two organizations or societies, also,—that devoted to chemistry primarily and that devoted to chemical engineering.

All of us recognize the fundamental nature of education and the importance of constantly discussing its ways and means. No teacher of experience is willing to arrogate to himself the decision that his method is the best one. An equally good tool in the hands of different artists gives different results, and some artists do astonishingly well with tools that seem impossible.

It is very important that we allot to everyone the right to reach their own conclusions and carry out their own program, though there is much difference of opinion along the line as individuals responsible for the program must eventually reach their own decisions. One should not hesitate to reach his own conclusions, even though all the others in the field disagreed with him. He must select his own means to the end. It is to be hoped, however, that in making our decisions, each of us will still keep his mind open to learn from the experience of others and not hesitate to change when experience indicates we should do so. It is particularly important that we should not assume that numbers constitute freedom from error or from bad judgment. It would be obviously wrong to assume that because four years are used by most institutions that four years is better practice. Such ideas would stop all progress. We must in our own minds keep these questions perpetually stirred up and allow nothing to be fixed. When we cease to make changes we are said to cease to grow.

The man who has made no errors is certainly to be congratulated, if he is not already dead.

It seems to me unnecessary for the teacher to be wedded to either the four-year idea, or the five or the six. We in chemical engineering are in the position that whether our students are to be called chemical engineers or whether they be graduate students, they will still keep coming. The need in industry is very great.

To sum it all up.

1. There is greater and greater need for highly trained men in the chemical engineering field.
2. These men should come from either or both, special extended curriculum for chemical engineering at particular institutions or
3. They should come from graduate work in chemical engineering.
4. The industry needs beginners at chemical engineering, whose training will be completed in industry.
5. The four year curricula will furnish the bulk of these men.

COOPERATION FROM FUNDAMENTALS

After thus concluding the written discussion of the topic assigned to me, may I be allowed to emphasize the importance to chemical engineering education of the question raised in this open meeting and in group discussion, of cooperation by other departments in our technical schools—particularly the Department of Chemistry. In institutions where the Department of Chemistry is directed by the individuals responsible for chemical engineering, with a thorough interest in the subject, as well as experience therein, this question could never arise. In other cases where the two subjects are in separate departments nothing is gained in evading the questions which have been raised directly at this meeting or at other times, or inferrentially in the discussion. For instance, the question has been raised with myself regarding the quality of this cooperation in our case. I believe this is

as good as could be expected. It probably is much better at some institutions than at others, but it doubtless will improve in all cases. Occasionally the attitude in the matter is amusing, though sometimes not so for the student, who becomes entangled between the upper and the nether millstone of these two departments.

You know, one was taught by the Greeks when one received a gift horse to look it over carefully in the mouth. When, therefore, I was asked by the head of the Chemical Department whether I would cooperate in the forming of a separate Department of Chemical Engineering at the Ohio State University, this memory of the old Greeks was stimulated by rumors circulating among the graduate students to the effect that it was felt that the tendency of graduate students at our university to elect in undue numbers the subjects in industrial chemistry and chemical engineering might be curtailed to a large extent if the work were in a separate department. Then the young men who were picked as assistants in chemistry coming from other schools could be discouraged or actually forbidden from electing their thesis or dissertation in the work of the chemical engineering department. Sure enough, within 30 days after the trustees had made the separation, the graduate students were notified they could not hold positions in the Chemistry Department if they elected theses in the Department of Chemical Engineering. They were even told there was a university rule against it, although when the speaker was a member of the Chemistry Department he had assistants and instructors from other departments in the university taking work with himself, as a member of the Chemistry Department, and in fact has such students today. The hardship is naturally very great upon the young men coming from institutions not having departments of chemical engineering and wishing to take such work, but requiring financial help most readily obtained in the Chemistry Department with large groups of beginning students, customarily requiring young graduate students as helpers. The effect of this particular lack of cooperation is upon a few

graduate students, only, and does no harm obviously to chemical engineering. Without doubt, the professors of chemistry in any given institution where this had been done—and one or two others have been mentioned here, will in a very short time think better of such treatment of students. It is a passing phase merely, in my opinion, of the cooperation problem, and in any event will do little harm to the teaching of chemical engineering. It merely serves to lighten the teaching load in a subject where the securing of adequate help is probably always to be a difficult budget matter, except with unusual perspicacity on the part of budget authorities.

As this whole matter is merely a question of the ideals of individual professors or departments, it will always be possible on the part of such to reject the application of any student should it be understood from his application that his elections may go outside the Chemistry Department. He will not know of differentiation in university subdivision, and can of course be required in connection with his applications to state where his ambitions lie.

It seems to be agreed that no first-class graduate school in an American university would tolerate limiting graduate student election in such fashion. At any rate it could not hold its head very high if it stood for the practice of curtailment of free election by graduate students. Obviously, to anyone familiar with teachers of chemistry, this abuse of the innocent bystander, the graduate student, will right itself and this occasional short-sighted chemistry policy will cease, for the teachers of chemistry are not going to be patient with it. Already exceptions have been made in our own university in the case of some graduate students who desire to major in work in the Chemical Engineering Department.

There is another form of the cooperation question which should be touched upon and I think it is much more important. That is the matter of attitude of mind of the teachers of elemental, fundamental subjects. I have long had a feeling quite different than that of Professor Lewis in the matter of young instructors, although I recognized the force

of his point of view. I have had the feeling it was too bad that the beginners could not have more contact with teachers of experience. I have felt that beginners in chemistry should not be submitted to this great raft of even "big young men" from smaller colleges.

It has always seemed to me that these beginners should come in contact with the best teaching experience with which they could be thrown in contact, if for no other reason, because of their high mortality in college. Many of these men stay only one or two years. It seems a pity to have them in touch with only juvenile teachers. When these latter men are the upstanding men that Professor Lewis mentioned, that is so much gained.

Lately I have come upon another angle of the thing, in connection with graduate work in the universities. The pressure of older men, professors particularly, to develop thesis students is becoming so acute in some of our institutions, that one begins to understand statements we hear from time to time about the "desirable class of students."

I remember sitting beside the Dean of our Graduate School, Dr. McPherson, and on the other side of him was a professor of a modern language. The Dean asked this man in a perfectly guileless, innocent, unpremeditated way, "What effect is it having upon your department to lose engineering students," who had been withdrawn from it by action of our faculty. The response came "We are rid of a very undesirable class of students." He evidently said that from his heart. There was no question about what he meant. He didn't wish to have engineering students, though other instructors in the same department spoke well of them. In fact, I have talked to other instructors in that same department who said the engineering students were the best students they had. Now, what did the professor mean? I did not learn at once what he meant, but I have learned since I heard other professors talk about the same undesirable students. What they meant was, "Those men will never be graduate students to me." That is one of our biggest problems in

the university to-day. Like the other lack of cooperation, I think it is a passing phase, but a serious matter. It merely means they are paying no attention whatever to men who will not major with them. That I think is a thing we must find some way of curing. What does it mean? It means we have lost the old teaching contact that loved to bring on people. We are looking on this teaching work from the angle which promotes these men in University standing in proportion to the number of graduate students who major with the professor and not how much service is he rendering society through the great incidental group of students who will never major with him. He is not willing to cast his bread upon the water.

I believe this phase of the cooperation problem with engineering teaching in general will perhaps always be with us, for it is difficult to get at the inner motives of those who teach. The great bulk of teachers, however, who are real men will be like those whom Professor Lewis has so ably discussed in his brief oration upon the teacher himself. The real teacher will always be interested in the growth of pupils. He will be like the university president whom I recently heard criticized on the score that he was too interested in men to be interested in education. These teachers will be too interested in adding their mite to the growth of the pupils who pass through their classes from year to year to be much worried about the opinion of the authorities regarding themselves based upon the number of flies they can attract to their graduate molasses.

THE USE OF DIAGRAMS IN OBJECTIVE EXAMINATIONS IN MECHANISM

BY JOHN FLODIN,

Assistant Professor of Mechanical Engineering, University of Minnesota

In order to provide a fairly permanent and reliable measure of achievement in the course in mechanism offered electrical engineering students at the University of Minnesota, it was decided to work out an objective or "new type" examination. There is considerable literature available in this field, but the work covered has been along other lines of learning than in engineering, and the difference is greater than is apparent at first glance. In engineering courses intended to aid the student in acquiring new skills or mastering new principles, or to teach him new uses of principles previously learned, the building up of objective examinations becomes more difficult than in courses whose content is more purely informational in character. Even informational engineering material is not readily handled by the new type examinations as commonly used, that is, without the use of diagrams or illustrations. The descriptions are apt to be so long and obscure as to make them difficult to understand. Further, the use of long descriptions instead of diagrams seems to produce antagonism among the students, since it means a negation of the principle that drawing is the engineer's language, a lesson that has been carefully emphasized during the students' previous college career. The obvious remedy is to introduce incomplete diagrams that the students would be required to complete so as to make an accompanying formula true, or complete diagrams from which formulas are to be written or derived, or about which definite statements are to be made.

An example of each type of diagram will serve to illustrate. A contemplated descriptive sentence, completion test type,

appeared as follows, the words to be filled in by the students being here placed within parentheses:

"The angular velocities of the two cranks of a four-bar linkage are (inversely) (proportional) to the lengths of the perpendiculars drawn from the (fixed) (centers) to the (center) (line) of the connecting rod; also (inversely) (proportional) to the distances from the (fixed) (centers) to the point of intersection of the center line of the (connecting) (rod) and the (line) of (centers), produced if necessary."

Using the incomplete diagram the question becomes:

"Complete the figure so as to make the following statement true:

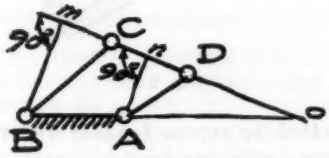

FIG. 1.

Ang. vel. BC : Ang. vel. $AD = Am : Bn = AO : BO$."

In the figure reproduced herewith, the heavy, ruled lines and the capital letters indicate the original diagram as given in the paper, the dotted, free-hand lines and the lower case letters being the completion work expected of the student for full credit for all the steps involved in the question. In the instructions given at the beginning of the examination paper the student has been told that "where the question calls for the completion of a diagram free-hand sketching only is required. To make your intention clear, all angles intended to be 90° must be so marked. Your score will be based on the number of blank spaces correctly filled in, plus the number of steps correctly made in completing diagrams."

The following question is an example of the use of a complete diagram on the basis of which the student is to do a definite task:

"In the figure, the rods A and B are connected to the oscillating disk by means of pins located as shown. If A has a velocity of one foot per second, what is the velocity of B? (Sin 40° = .643, cos 40° = .766, tan 40° = .839, sec 40° = 1.305.)"

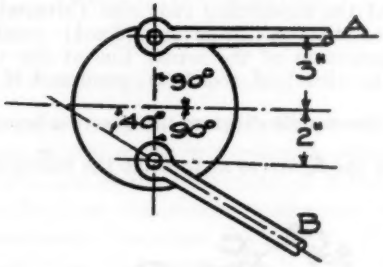

FIG. 2.

It will be seen that for anyone familiar with the underlying principles the calculation involved is extremely simple. In other words, the students' understanding of, and ability to use, these principles is tested without much waste of his time either in writing or in arithmetical computations.

In all, 16 diagrams were used in the final examination, with 66 scoring points, the rest of the paper consisting of ordinary completion questions, giving a total number of scoring points of 189. In deciding whether or not a diagram should be used, the possibility of expressing the question briefly and clearly without a diagram was often the determining factor, but in general the questions of an informational nature were written without diagrams, the use of figures being fairly well reserved for questions intended to test the students' ability to work the types of problems covered in the course.

With two or three exceptions, the students were sent to the blackboards to work problems for from twenty to forty minutes at each meeting of the class, other than the meetings devoted to written quizzes. The blackboard work was supposed to be graded every day, but in order to avoid the neces-

sarily great errors due to hasty marking, the work was graded only when there was ample time for careful consideration of each student's progress with his task. The means of the seven grades thus available furnish a somewhat loose measure of the student's ability to work problems. Grades are also available from two fifty-minute written quizzes, during each of which the students were required to work five problems.

If we accept as a criterion of the students' ability to work problems a grade obtained by giving equal weight to the average of the blackboard grades and the average of the problem quiz grades, we may compare the scores earned in the final objective examination with this criterion. This gives the following coefficients of correlation:

Scores earned in diagram questions to criterion $.72 \pm .043$
Scores earned in completion questions other than diagram questions to criterion $.51 \pm .067$.
Number of students 56

Since the criterion here used is far from a reliable measure of the students' ability, the coefficients given above can be accepted only as a general indication of the value of diagrams in conjunction with completion tests. The rather high correlation between scores earned in other than diagram questions, that is, in questions pertaining chiefly to general information rather than to mastery of principles and ability to work problems, seems to suggest that both the ability to acquire general information and the ability to master principles are dependent on the same characteristics, probably mainly on intelligence and on interest.

CONFERENCE ON DRAWING

At the annual meeting of the Society for the Promotion of Engineering Education held in Iowa City in June 1926, a Conference of teachers of drawing and design was held under the auspices of the Committee on Drawing and Design with the following members present:

F. P. Schone, State University of Iowa,
H. M. McCully, Carnegie Inst. Technology,
S. J. Boller, Okla. A. & M. College,
J. A. Herrington, Okla. A. & M. College,
R. P. Hoelscher, University of Illinois,
F. A. Heacock, Princeton University,
Wm. G. Smith, Northwestern University,
R. F. Edgar, University of Pittsburgh,
E. B. Parker, Washington State College,
E. C. Baker, Oklahoma A. & M. College,
H. C. Thompson, Jr., State University of Iowa,
C. E. Krause, Oklahoma A. and M. College,
H. H. Jordan, Urbana, Illinois,
A. L. Grover, Orono, Maine,
F. G. Higbee, State University of Iowa,
B. M. Burgman, University of Louisville,
Thomas E. French, The Ohio State University,
Thos. G. Caywood, State University of Iowa,
W. B. Wendt, University of Louisville,
C. V. Mann, University of Missouri,
J. Charles Rathbun, South Dakota State School of Mines,
Carl T. Humphrey, Villanova College, Villanova, Pa.,
W. E. Mott, Carnegie Institute of Technology,
I. H. Prageman, State University of Iowa.

At the request of the Commitee in charge, Professor Thomas E. French made a brief presentation of the situation with respect to drawing standards and explained to the group that a committee was now being organized under the joint sponsorship of the S. P. E. E. and the A. S. M. E. under American

Engineering Standard's Committee procedure to propose a set of standards for drawing and drafting room practice. Following the presentation by Professor French, the participation of the Society in this project was discussed by Dean Jordan of Illinois, William G. Smith, of Northwestern, R. P. Hoelscher of Illinois, H. M. McCully of Carnegie Institute of Technology, F. G. Higbee of Iowa, A. L. Grover of Orono, Maine, C. V. Mann of University of Missouri, School of Mines, and the general sense of the meeting as expressed in a formal motion was that the Committee on Drawing and Design approve and endorse the movement towards drawing standards.

It was further agreed in the Conference that the discussion would be advanced if details were omitted, and referred to the Committee for study; that a standard once proposed should be rigidly adhered to by teachers of drawing; that both teachers and others should be tolerant in considering new ideas advanced by the joint committee.

Following this discussion Professor Grover of Maine explained the organization meeting which was held under the auspices of the American Engineering Standards Committee in New York in December 1925, at which the decision to create a joint committee was reached.

Following the discussion on standards, Professor C. V. Mann made a brief report on the method of teaching descriptive geometry employing concrete objects rather than points, lines, planes, etc.

Following the discussion on descriptive geometry the Conference discussed in an informal round table discussion the amount of lettering given in a course and the method of teaching it, the number of credits allowed in a course in Engineering Drawing, and the content of courses in Machine Drawing.

Following the discussion the motion was made and carried that the conference be continued and made a regular part of the annual meetings.

F. G. HIGBEE,
Acting Secretary.

MEETING OF SECTIONAL EXECUTIVE COMMITTEE AMERICAN ENGINEERING STANDARDS COMMITTEE

The meeting was held in Room 1101 of the Engineering Societies Building, New York City, January 22, 1927.

There were in attendance: J. Franklin Meyer, Chairman; S. A. Moss, Vice-Chairman; C. M. Spofford; Preston S. Millar, Secretary; S. McK. Gray, Assistant Secretary; E. V. Huntington, Chairman Subcommittee on Mathematical Symbols, and F. J. Schlink of A. E. S. C. headquarters.

Designations of Subcommittees. It was agreed that it would be well to separate in a measure the work upon symbols from that upon abbreviations. In order to clarify the situation in this particular, the Executive Committee adopted a resolution introducing the word "Symbols" into the name of each subcommittee as follows:

Subcommittee on Symbols for Mechanics, Structural Engineering, and Testing Materials,
Subcommittee on Symbols for Hydraulics,
Subcommittee on Symbols for Heat and Thermodynamics,
Subcommittee on Symbols for Photometry and Illumination,
Subcommittee on Aeronautical Symbols,
Subcommittee on Mathematical Symbols,
Subcommittee on Electrotechnical Symbols Including Radio.

Additional Subcommittees.—The Executive Committee considered a communication from Col. W. A. Mitchell, transmitting War Department pamphlet dated March 25, 1924, entitled "Topography and Surveying—Conventional Signs." The Executive Committee regarded favorably Col. Mitchell's recommendation that the symbols contained in this pamphlet be adopted by the Sectional Committee, but qualified its view by advocating consideration of elimination of purely military symbols and perhaps inclusion of certain other germane sym-

bols not included in the War Department publication, as symbols employed in soil surveys, forest surveys and aeronautics. With a view to consideration of such matters it was decided to set up a subcommittee (No. 8) on *Navigation and Topographical Symbols* with the following personnel as a nucleus:

Prof. C. M. Spofford,
Prof. Geo. L. Hosmer,
Col. W. A. Mitchell,

Consideration of requirements in the field of naval architecture mentioned in the report of the Steering Committee resulted in a decision not to recommend organization of a subcommittee on this subject at present.

In application of the view of the Executive Committee that best results will be obtained if the work on abbreviations is separated from that on symbols, a resolution was adopted that there be set up a Subcommittee (No. 9) *On Abbreviations for Scientific and Engineering Terms.* It was the sentiment of those present that while this Subcommittee should confine its formal activities to abbreviations which lie strictly within the purview of the Sectional Committee, it might be helpful if it would include informally and for purposes of recommendation any related matters such as spelling and style which may impress the Subcommittee as in need of clarification or standardization. Professor W. T. Magruder, Ohio State University, Columbus, Ohio, was designated chairman, subject to acceptance. It was understood that the chairman of this subcommittee will nominate his own committee. It was suggested, however, that the membership should include editors of engineering society journals or their representatives.

With a view to promoting the work of the new Subcommittee on Abbreviations, there will be prepared at the Secretary's office and transmitted to the Chairman of the subcommittee a parallel column table of scientific and engineering abbreviations now in use in so far as the information is readily available.

REPORTS OF SUBCOMMITTEES

Subcommittee on Symbols for Mechanics, Structural Engineering and Testing Materials.—A written report received from Dr. John T. Faig, Chairman, recounted the organization of the Subcommittee, including minutes of the organization meeting. The Executive Committee noted with satisfaction that the Subcommittee had set up an Executive Committee to facilitate the work of the Subcommittee. Dr. Faig's communication indicated that the work of the Subcommittee had been carried on by correspondence subsequent to the organization meeting. It included, with slight revision, a list of symbols of the S. P. E. E. published in 1918, presented as a tentative list under consideration by the subcommittee.

The Executive Committee expressed the hope that with the aid of the organization set up by the Subcommittee, and in view of the early start made by the Subcommittee, further reports of its work would show definite progress in the approval of an extensive list of symbols.

Subcommittee on Symbols for Hydraulics.—A report was received from Professor G. E. Russell, Chairman, referring to the minutes of the organization meeting. This Subcommittee has set up seven special committees charged with the formulation of lists of recommended symbols in the following subjects: Theoretical Hydraulics, Hydrology, Water Power, Pumps and Pumping Machinery, Sanitary Engineering and Water Piping, Irrigation, and Turbines. Professor Russell's report indicated that this Subcommittee expects to make good progress in the near future.

Subcommittee on Symbols for Heat and Thermodynamics.—Chairman Moss reported orally on the work of the Subcommittee. The Subcommittee has under advisement a tentative list of symbols which it has submitted informally to the International Electrotechnical Commission and which is understood to be under consideration by that body. The Subcommittee is engaged in prosecuting its work with this list as a basis.

In view of I. E. C. consideration of symbols under advise-

ment by the Subcommittee, it was the view of the Executive Committee that the Subcommittee should carry its work forward as rapidly as practicable and that the Sectional Committee should bring this list of symbols to as advanced a stage as practicable with a view to making the list available for the I. E. C. meeting in September, 1927.

Subcommittee on Symbols for Photometry and Illumination.—The Secretary reported that canvass of affiliated organizations had elicited from those interested in this subject very general approval of the plan of adopting the symbols of the existing American Standard, without setting up a Subcommittee to function in this field. The Executive Committee endorsed this view with the understanding that the list of symbols heretofore adopted and now recognized as an American standard is subject to revision under A. E. S. C. procedure as required.

Subcommittee on Aeronautical Symbols.—A communication from Dr. Jos. S. Ames, Chairman, transmitted an approved list of symbols and a chart showing comparison of such symbols with those in use by various organizations in this country and abroad. The Executive Committee accepted this report and instructed the Secretary to communicate its thanks to Dr. Ames. The Subcommittee is requested to stand by for possible further consideration of matters that may require attention in the course of the further work of the Sectional Committee.

Subcommittee on Mathematical Symbols.—Professor E. V. Huntington, Chairman, presented oral and written reports indicating the substantial completion of the work of this Subcommittee. He presented a list of symbols as approved by the Subcommittee. The Executive Committee accepted the reports and extended its thanks to the Subcommittee, with the request that it stand by for possible further activities in connection with the furtherance of the work of the Sectional Committee.

Subcommittee on Electrotechnical Symbols Including Radio.—Chairman Meyer reported on the organization of the Sub-

committee for its task, including the appointment of Mr. R. W. E. Moore vice Mr. H. G. Knoderer as Chairman of the Special Committee on Supply Material. The minutes of the organization meeting of this Subcommittee show that six such Special Committees were set up to deal respectively with (1) Letter Symbols, (2) Electric Power, including Interior Wiring, (3) Radio, (4) Supply Material, (5) Traction including Railway Signalling, (6) Telephone and Telegraph. The Executive Committee expressed the hope that, with the aid of the organization set up by the Subcommittee, further reports of its work would show definite progress in the approval of an extensive list of symbols.

Committee on Correlation of Electrical Symbols.—This Committee, which has been authorized for the purpose of coordinating the activities of several A. E. S. C. Sectional Committees in the electrical field as regards the use of electrical symbols, was reported by Chairman Meyer as not yet having organized.

Coordination of Symbols.—The Assistant Secretary of the Sectional Committee has posted to coordinating cards all symbols which thus far have been communicated by subcommittees to the Secretary's office. In this process use of a given symbol to represent different concepts and use of different symbols to represent the same concept are brought into relief. The Executive Committee has directed the Secretary to call the attention of the Chairman of the respective subcommittees to notable instances of these kinds and to ascertain which, if any, concepts, in the opinion, of subcommittees, require to be reconsidered.

In this connection Dr. Moss has submitted as a personal contribution to the work of the Committee a statement of his views as to certain principles underlying the project of this Sectional Committee, and embodying a list of certain symbols which are employed in several branches of science.

The Executive Committee received this communication with an expression of appreciation to Dr. Moss and directed the Secretary to include it in the review of symbols for coordinat-

ing purposes. The statement of principles as put forward by Dr. Moss is appended hereto as a matter of record.

Submission of Subcommittee Symbol Lists to Sectional Committee.—In view of submission of lists of symbols by the Subcommittee on Aeronautical Symbols and Mathematical Symbols respectively, the Executive Committee directed the Secretary to circulate these lists among the members of the Sectional Committee with letter-ballot for approval, after communicating with the Subcommittees regarding cases of possible conflict and diverse usage and affording the Subcommittees opportunity, if desired, to reconsider their lists before they shall be submitted to the Sectional Committee.

These lists, when submitted to the members of the Sectional Committee for approval by letter-ballot, should be accompanied by statement of any conflicts or diverse usages which may be considered to be significant.

Note Concerning Publication of Lists of Symbols when Approved.—The sentiment of the Executive Committee in regard to publication of approved symbol lists favored publication of a complete list of symbols in each field, with repetition in the several lists, of symbols employed in more than one field. The publication of one general list of all scientific and engineering symbols was not favored.

PRESTON S. MILLAR,
Secretary.

MEMORANDUM SUBMITTED BY DR. S. A. MOSS

General Principles

1. A symbol is a letter or sign used in a formula as a substitute for any numerical value. Thus, in the formulas

$$F = Ma, \qquad E = IR$$

all of the letters are symbols.

2. A shortened expression for the name of a quantity is an abbreviation and not a symbol. Thus W denoting weight in a formula is a symbol but g denoting grams is an expression

such as 98 g. is an abbreviation. R in the equation above is the symbol for resistance, but Ω, denoting ohms in the expression 98 Ω, is an abbreviation.

3. The matter herewith applies to symbols and not to abbreviations or signs for operations.

4. A symbol is invariably a single letter or sign. Thus, FW cannot be a symbol for Face Width.

5. Letter subscripts denote values of a general quantity under special conditions, or at special states, such as

c_p = specific heat at constant pressure,
c_v = specific heat at constant volume,
v_{liq} = specific volume of liquid water,
v_s = specific volume of dry steam.

6. Numerical subscripts denote values of a general quantity at designated points in an apparatus or process, such as

P_1 = initial pressure,
P_2 = final pressure,
v_{s_1} = specific volume at point 1,
v_{s_2} = specific volume at point 2.

7. Preference is given to lower case letters for specific quantities, *i.e.* values per unit area or the like. Names of specific quantities often end in "ity" as "conductivity" or "resistivity." Upper case letters are preferred for total quantities. Names of total quantities often end in "ance" as "conductance" or "resistance."

8. However, this use of upper and lower case is not always adhered to.

9. There are not letters enough to give independent symbols to all quantities in all branches of science, so the same symbol is frequently assigned to different quantities which are not likely to occur in the same discussion.

10. In some cases, it has not been possible to reach agreement on a single symbol for a given quantity and two optional symbols are given.

11. The same symbol shall be used regardless of the system

of units, except where more than one system of units is used in a discussion. Thus p is the symbol for "pressure" whether absolute pressure or pressure above atmosphere, and whether in pounds per square inch, millimeters of mercury or any other unit. An exception is

t = temperature above freezing point of H_2O,
T = absolute temperature.

12. In order to increase the clarity of printed matter, symbols alone or in equations are always to be printed in italics, the text being in Roman.

LETTER TO THE SECRETARY

Dear Dean Bishop: It gives me great pleasure to transmit to you herewith signed and sponsored applications from thirteen members of this School's staff who desire to become members of the S. P. E. E.

You may be interested to know that this unprecedented manifestation of interest by our people is due in part to the recent formation of the Greater New York-New Jersey Section of the Society, but an even more influential factor is the current investigation of Engineering Education which, while directed primarily to the service of the colleges, is proving invaluable with reference to our non-collegiate courses.

AN AUTOMOBILE TRIP TO THE MAINE MEETING

In connection with the Orono meeting which will be held June 27 to 30, 1927, plans are being made by the University of Vermont to have that as a meeting place for those coming by automobile from points west of the Hudson River. Burlington is a point through which one would be likely to pass en route for Orono. This takes one along the shores of Lake Champlain, through the beautiful Green Mountains of Vermont, and the stately White Mountains of New Hampshire and the historic towns of Maine across three watersheds, to Orono. Vermont plans to entertain all those who come by providing a dinner and will assist in locating over night accommodations. It is planned to start a caravan from this point which will be led by Dean Votey. In passing through the Green Mountains he will conduct the caravan by the base of Mt. Mansfield, the highest mountain in the State and through Smugglers' Notch, which is a point of historic interest. The complete route and final plans will be published in a later JOURNAL.

AMERICAN SOCIETY OF CIVIL ENGINEERS. FREEMAN FUND TRAVELING SCHOLARSHIP

The American Society of Civil Engineers is about to take on a new activity as sponsor for a traveling scholarship in Europe. This way suggested in 1924 when Past-President John R. Freeman established a fund of the Society "for the encouragement of young engineers," since designated as the "Freeman Fund." A part of the income, $1,800, has been made available for special study abroad during one year beginning July 1, 1927.

This period is to be devoted to a study of the theory and practice of hydraulics particularly as exemplified in the hydraulic laboratories of Europe, more especially those of Germany. For the present, candidates for this scholarship will be limited to junior professors, instructors, or assistants in American technical schools of recognized standing in which the study of hydraulics forms an important part of the curriculum.

Study in the great engineering colleges of Europe has long been considered a fascinating goal. Some fortunate young teacher is going to find the door suddenly opened for him to attain this opportunity, with his expenses paid, with the moral support of a great engineering body, and with access accorded to some of the greatest hydraulic laboratories of the world under ideal conditions.

It is suggested that members of the Society give this announcement publicity either by making personal suggestions to friends or by seeing that the essentials are repeated in college papers or in other mediums where they will come to the attention of those who may best be able to take advantage of the opportunity. A complete statement of the conditions under which the scholarship will be awarded and full details of the requirements may be obtained from the Secretary of the American Society of Civil Engineers, 33 West 39th St., New York, N. Y.

THE ENGLISH DEPARTMENT

One striking thing brought out by the Preliminary Report of the Board of Investigation and Coordination published in the December JOURNAL is the fact that of over five hundred teachers of extended experience and more than eight hundred leading engineers who expressed their opinion as to the studies which should form a core of fundamentals in all engineering curricula, 95.5 per cent regarded English Composition as of prime importance; 73.5 per cent regarded English Speech; and 45.5 per cent English Literature as of similar value. This places English Composition second only in importance to physics and mathematics in the esteem of those replying to the questionnaire, with English speech and English literature falling only a little below in popularity. As the Chairman looks back over twenty years to the time when Professor Earle of Tufts first began his inspired appeal for training in English as part of the education of an engineer, as he recalls how slowly and reluctantly the response came at first to that appeal, he feels very much as if the millennium had somehow quite suddenly and unexpectedly arrived. One's faith is often so small that an answer to prayer, like this, comes as something of a shock. The day so long hoped for is at last here when there is apparently a full appreciation of the place training in English should have in the preparation of an engineering student for his professional work and for life.

But it is certainly no time for complacency. The situation is fraught with insidious dangers and impediments to progress. Engineering educators and members of the engineering profession have recognized the essential importance of this element in the curriculum. This is a rather generous admission especially when one is familiar with how sorely every hour required for graduation is needed for fundamental sciences

and for engineering subjects. There is danger that, having salved their consciences by this concession, those entrusted with affairs will fail to provide time in the remodelled curriculum for this essential work in English, or to assure conditions favorable for its success. At the present moment comparatively few engineering students are receiving instruction in English under ideal conditions. In many of the larger institutions they are herded over into the already congested English sections in the Arts college, where they are neither understood nor appreciated. As aliens in the enemy's country, they develop little except inferiority complexes, and a definite distaste for writing. In several colleges, a half attempt is made to give instruction to the engineering students in segregated sections, where there shall be a more sympathetic study of their needs and aptitudes. But how often are these engineering sections in charge of the most experienced and skilful teachers of the English faculty? I wonder how many engineering students are at present actually being taught by men of professional rank. Possibly it might not be irrelevant, (or two impertinent) to ask what inducements beyond a magnificent opportunity for heroic sacrifice, the engineering colleges are prepared to hold out in order to secure for this essential work men of the requisite scholarly training and professional experience. These are all rather large considerations, since they involve administrative policies and departmental budgets, but they will surely need to be weighed carefully, if English is to justify its place in the curriculum as second only to physics and mathematics in importance.

The Committee on English is, of course, in a much more critical position than the deans and engineering teachers who have thus thrust English into a place near the top. The temptation is strong to regard the task set before us as accomplished, and, of course naturally enough, to take two much credit to ourselves for having brought it all to pass. As a matter of fact the Committee on English has placed on it by this demand of the engineering educators, a serious obliga-

tion. In the reshaping of curricula which is bound to follow this report of the Board of Investigation, the Committee on English will be called on to define the objectives for this work to hold high the ideals which should animate it, to help save it from too great an emphasis on its practical side, to inspire teachers of English everywhere to make their courses rich in cultural and humanistic content, and above all to correlate and integrate the work in English with the rest of the engineering curriculum so that our engineering students shall develop in their ability to express themselves contemporaneously with the growth in their find of ideas, and shall find, with increasing satisfaction, the broadening effect of the reading of good literature, as an antidote to its narrowing tendency of their specialized studies.

As the Chairman of the Committee on English begins to plan for the Joint Conference of Deans, Administrative Officers, and teachers of English at the Maine meeting of the Society next June, he is rather overwhelmed by a sense of responsibility to the cause of engineering education,—a new sense of obligation placed on us all by this indication of the place which English must take in the future education of engineers. Some of the questions raised in this communication will have to be answered soon in a definite and conclusive way. The Committee would appreciate greatly suggestions as to how the conference at the University of Maine may be made most helpful in preparing for whatever forward step is needed. Suggestions may be addressed to J. Raleigh Nelson, 927 Forest Ave., Ann Arbor, Michigan.

NEW MEMBERS

ASHBY, GEORGE F., Professor of Drawing, Northeastern University, Boston, Mass.

BAIRD, CHARLES O., Jr., Instructor in Civil Engineering, Northeastern University, Boston, Mass.

BAKER, CHESTER P., Assistant Professor of Chemical Engineering, Northeastern University, Boston, Mass.

BARCLAY, STANTON D., Instructor in Mechanical Technology, Pratt Institute, Brooklyn, N. Y.

BERRY, CHARLES W., Professor of Heat Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

BRANN, BERTRAND F., Associate Professor of Chemistry, University of Maine, Orono, Me.

BRUCE, ROBERT, Professor of Accounting, Northeastern University, Boston, Mass.

BURLEY, JOHN W., Head, Machine Work Department, Pratt Institute, Brooklyn, N. Y.

BURT, FREDERICK A., Associate Professor of Geology, A. & M. College of Texas, College Station, Tex.

CARR, CLIFFORD C., Instructor in Electrical Technology, Pratt Institute, Brooklyn, N. Y.

CAULFIELD, JOHN G. L., Instructor in Chemistry, University of Maine, Orono, Me.

CHATFIELD, CHARLES H., Associate Professor of Aeronautics, Mass. Institute of Technology, Cambridge, Mass.

COLSTON, ALBERT L., Principal, Brooklyn Technical High School, Brooklyn, N. Y.

COFLEY, JOHN O., Instructor in Drawing, Northeastern University, Boston, Mass.

DAVIS, EDMUND P., Instructor in Mathematics, Pratt Institute, Brooklyn, N. Y.

DOLL, ALFRED W., Instructor in Mechanical Technology, Pratt Institute, Brooklyn, N. Y.

ESTES, PHILLIP H., Instructor in Electrical Engineering, Northeastern University, Boston, Mass.

ESTES, STANLEY G., Assistant Professor of English, Northeastern University, Boston, Mass.

GAASBEEK, RICHARD M. VAN, Head, Department fo Woodworking, Pratt Institute, Brooklyn, N. Y.

GARNER, TURNER F., Professor and Dean, School of Business Administration, Northeastern University, Boston, Mass.

GRAMSTORFF, EMIL A., Associate Professor of Civil Engineering, Northeastern University, Boston, Mass.

HART, CLARENCE E., Instructor in Civil Engineering, University of Maine, Orono, Me.

HATCH, FORREST M., Instructor, Northeastern University, Boston, Mass.

HOSTETTER, HARRY C., Instructor in Physical Elements of Engineering, Pratt Institute, Brooklyn N. Y.

IMMEDIATO, GERARDO, Assistant Professor of Machine Design, Brooklyn Polytechnic Institute, Broklyn, N. Y.

JAMES, WALTER H., Associate Professor of Mechanical Engineering Drawing, Massachusetts Institute of Technology, Cambridge, Mass.

JENNESS, LYLE C., Instructor in Chemistry, University of Maine, Orono, Me.

JOHNSON, ELMER W., Assistant Professor of Electrical Engineering, University of Minnesota, Minneapolis, Minn.

JOHNSON, HERMAN P., Associate Professor of English Literature, University of Virginia, University, Va.

KENT, BENJAMIN S., Associate Professor of Mechanical Engineering, University of Maine, Orono, Me.

LAKE, WILFRED S., Instructor in Administrative Engineering, Northeastern University, Boston, Mass.

LAMBE, EMERSON P., Instructor in Physical Elements of Engineering, Pratt Institute, Brooklyn, N. Y.

MCDANIEL, JAMES E., Director, Co-operative Courses, The Georgia School of Technology, Atlanta, Ga.

MCGUIRE, WALDEMAR S., Assistant Professor of Chemical Engineering, Northeastern University, Boston, Mass.

MARSH, HORACE W., Head, Department of Mathematics and English, Pratt Institute, Brooklyn, N. Y.

METZENHEIM, HENRY H., Instructor, Newark College of Engineering, Newark, N. J.

MILLER, FORREST E., Instructor in Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn.

MILLER, HARRY P., Instructor in Electrical Technology, Pratt Institute, Brooklyn, N. Y.

MONTGOMERY, ARTHUR B., Instructor, Northeastern University, Boston, Mass.

NEWMAN, DERWOOD A., Instructor in Chemistry, Northeastern University, Boston, Mass.

NORTON, PAUL T. JR., Instructor in Mechanics, University of Wisconsin, Madison, Wis.

PERKINS, PAULENE, Instructor, University of Maine, Orono, Me.

PICKETT, WILLIAM J., Assistant Professor of Mathematics, Cooper Union, New York City.

PRICE, JOHN R., Associate Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.

RICHMOND, RUSSELL F., Instructor in Drawing and Architecture, University of Arkansas, Fayetteville, Ark.

ROGERS, ALLEN, Supervisor, Industrial Chemical Engineering, Pratt Institute, Brooklyn, N. Y.

SCHWEIZER, PAUL E., Instructor, Newark College of Engineering, Newark, N. J.

SEASHORE, CARL E., Dean, Graduate College and Professor of Psychology, State University of Iowa, Iowa City, Ia.

SIMPSON, EWING G., Assistant in Electrical Engineering, University of Virginia, University, Va

SPEAR, JOSEPH, Professor of Mathematics, Northeastern University, Boston, Mass.

STEARNS, FREDERICK A., Assistant Professor of Mechanical Engineering, Northeastern University, Boston, Mass.

STRAHAN, SAMUEL A. S., Associate Professor of Chemistry, Northeastern University, Boston, Mass.

TAFT, THEODORE H., Associate Professor of Heat Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

TAYLOR, FLOYD D., Instructor in Physical Elements of Engineering, Pratt Institute, Brooklyn, N. Y.

THOMPSON, JAMES E., Instructor in Mathematics, Pratt Institute, Brooklyn, N. Y.

THORNBURG, PAUL M., Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn.

THUESEN, HOLGER G., Assistant Professor of Industrial Engineering, Oklahoma A. & M. College, Stillwater, Okla.

TOWLE, GEORGE W., Assistant Director of Co-Operative Work, Northeastern University, Boston, Mass.

WATSON, HARRY D., Assistant Professor of Mechanical Engineering, University of Maine, Orono, Me.

WHITE, HAROLD C., Assistant Professor of Chemistry, University of Maine, Orone, Me.

WHITE, WILLIAM C., Instructor in English, Northeastern University, Boston, Mass.

WHITTAKER, ALBERT E., Assistant Professor of Physics, Northeastern University, Boston, Mass.

WILLIS, CLODIUS H., Assistant Professor of Electrical Engineering, Princeton University, Princeton, N. J.

ZELLER, JOSEPH W., Charge, Mechanical Engineering Dept., Northeastern University, Boston, Mass.

ZORN, PAUL M., Engineer's Assistant, The Southern New England Telephone Co., 457 Greenwich Ave., New Haven, Conn.

Total new members since annual meeting, 174.

NEW MEMBERS BY INSTITUTIONS SINCE ANNUAL MEETING *

Institution	New Members
Northeastern University	22
Massachusetts Institute of Technology	15
Pratt Institute	13
Minnesota, University of	12
Purdue University	11
Maine, University of	9
A. & M. College of Texas	9
Pennsylvania State College	7
Kansas State Agricultural College	5
Brooklyn Polytechnic Institute	4
Virginia, University of	4
Illinois, University of	4
Armour Institute of Technology	3
Cooper Union	3
Georgia School of Technology	3
Ohio State University, The	3
Newark College of Engineering	3
Arkansas, University of	2
British Columbia, University of	2
Brown University	2
Carnegie Institute of Technology	2
Colorado, University of	2
Nebraska, University of	2
New York University	2
North Dakota, University of	2
Oklahoma A. & M. College	2
Pennsylvania, University of	2
Stevens Institute of Technology	2
Tennessee, University of	2
Texas Technological College	2
Tufts College	2
Wisconsin, University of	2
Alabama Polytechnic Institute	1
Case School of Applied Science	1
Clarkson College of Technology	1
Colorado Agricultural College	1
Colorado School of Mines	1
Florida, University of	1

* This list does not include new members not associated with educational institutions.

Idaho, University of	1
Iowa State College	1
Iowa State University	1
Kansas, University of	1
Lehigh University	1
Mexico College of Engineering	1
Michigan College of Mines	1
Michigan State College	1
Michigan, University of	1
Mississippi A. &. M. College	1
North Dakota Agricultural College	1
Princeton University	1
Syracuse University	1
Vermont, University of	1
Worcester Polytechnic Institute	1

53 institutions represented. Is yours represented? If not, why not?

YEAR BOOK

The following card was mailed to all members, March 1. If you have not received yours, fill out this blank and return it at once.

For the purpose of checking the accuracy of the entry which appears after your name in the year book, will you kindly fill out and return this card IMMEDIATELY.

Name .....

Title .....

Institution .....

(*address*) .....

Occupational Classification .....

(*C. E., E. E., English, Math., etc.*)

Mailing address .....

BOOK REVIEW

Fourfold Geometry. By DAVID BEVERIDGE MAIR. D. Van Nostrand Co. 1926. 187 pages, 61 diagrams. $2.75.

In twenty-five short chapters the author presents a remarkably clear, comprehensive, and comprehensible picture of the elementary geometry of the "flat" four-dimensional world. He makes almost constant use of the concise and image-evoking method of vectors and presupposes but little more than a familiarity with Cartesian geometry and the idea of conjugacy. The choice of subject matter, its arrangement, and the method of treatment make of this book an almost ideal approach to the geometry of relativity, particularly for one whose major interests are not in mathematics.

In the earlier chapters the vector idea is extended to the magnitudes of the fourfold, reference lattices are defined, and the fundamental quadratic function is introduced. This is followed by a consideration of operations involving vectors, a definition of the tensor operator, and the development of the ideas of projection, transformation, congruence, and reflection. Continuing from chapter nineteen, which defines the velocity vector, the topics in order of discussion are: The Rotation Operator, A Gravitationless Reference System, Measure of Distance, Composition of Velocities, the Geodesic, and The Laws of Motion. Fourteen pages are devoted to Answers to Exercises. In most cases the answers are given in such a way as to indicate the method of solution. On the last page is listed the symbols used with the articles in which they were introduced. The book is the more lucid because of the omission of much that might have been included. The following from the preface is noteworthy.

"In consequence of the revolution produced in mathematical thought by the principle of relativity, geometry falls naturally into three stages. The first stage is the geometry of Euclidean

space. The second stage brings the fourth dimension of the world into consideration and assumes the existence of straight lines. The third stage continues the discussion of the four-dimensional world and recognizes that straight lines do not exist and that their place is taken by geodesics. It is the second stage that is treated in this book."

K. D. S.